



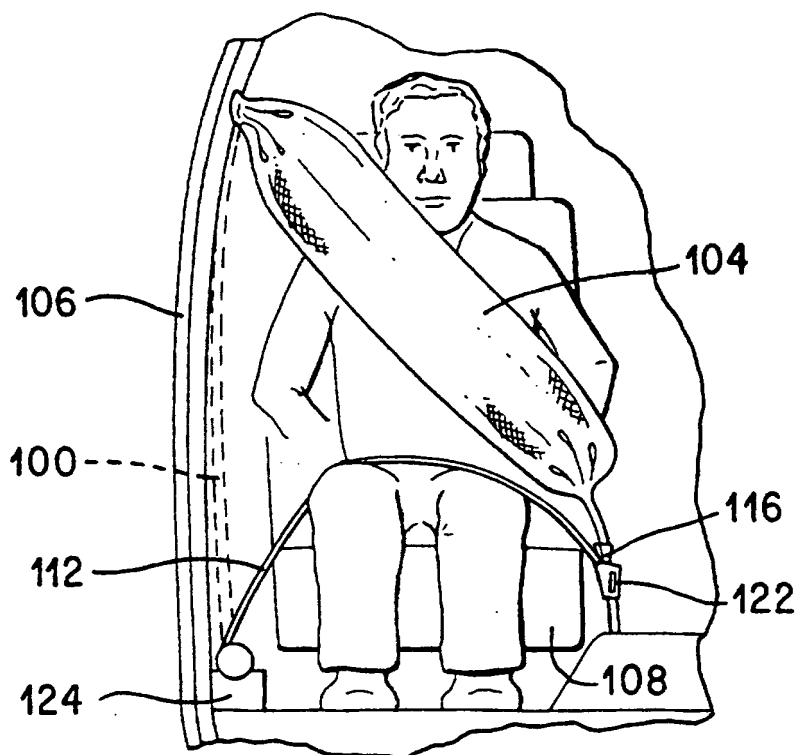
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(54) Title: INFLATABLE SEAT BELT SYSTEM

(57) Abstract

An inflatable belt portion (104) is attached to a lap belt portion (112) by stitching, some of which becomes progressively detached to dissipate the forces imposed on the inflatable belt portion (104). The inflatable belt portion (104) is inflated by a hybrid inflator. The lap belt portion (112) tightens against an occupant's lap when the inflatable belt portion (104) is inflated. A coupling member (116) removably couples the lap belt portion (112) to a retainer (122) at the inner side of a seat (108). When the coupling member (116) is removed from the retainer (122), the lap belt portion (112) is wound on a retractor (124) so that the inflatable belt portion (104) is moved to an out-of-the-way position.



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## INFLATABLE SEAT BELT SYSTEM.

5           This invention relates to a system for, and method of, providing an inflatable member, such as an inflatable bag or seat belt, in a vehicle and inflating the member to protect an occupant when a collision involving the vehicle occurs.

10

### BACKGROUND OF THE INVENTION

Safety of occupants in vehicles is an important concern to manufacturers of the vehicles and to the occupants of the vehicles. The manufacturers have disposed seat belts, 15 some partially or wholly inflatable, and inflatable air bags in the vehicles to protect the occupants when collisions involving the vehicle occur. An inflatable member (this term is used herein to describe an air bag as well as an inflatable belt or an inflatable belt portion) becomes 20 inflated upon the occurrence of a collision involving a vehicle to reduce the occupant's velocity below unacceptable rates and to limit the occupant's movement to enhance the occupant's safety. Many manufacturers have started to provide inflatable members for occupants of the front driver 25 seat.

Perhaps the most significant consideration in a vehicle containing an inflatable member relates to the fact that such a member cannot begin to restrain the occupant's 30 motion during-the vehicle collision until the occupant has moved into engagement with such member. Particularly in the case of air bags, which are typically deployed from the dashboard or steering wheel, this wastes an important portion of the time and deceleration space available to protect the 35 occupant against injury. This markedly reduces the occupant's protection from the level which can be provided if

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the restraint is initiated before the occupant has moved within the vehicle after the vehicle collision.

Non-inflatable seat belts now in use almost  
5 immediately engage the occupant when a collision involving a vehicle occurs. However, such seat belts suffer from certain significant disadvantages. For example, although certain selected designs of seat belts can, through the use of pre-tensioning devices, begin a restraint of the occupant earlier  
10 than the restraint provided by an air bag, such belts do not provide for control of the occupant's head motion. This shortened deceleration time, however, has caused markedly higher decelerations and loadings, at least of the occupant's head, and has produced less than desirable results from the  
15 standpoint of injury thereto.

Seat belts are also often of narrow physical construction and thus have not provided for the distribution of the restraining loads over wide areas of the occupant's  
20 body. This has resulted in unnecessarily high loads being imposed upon the occupant over the limited portion of the occupant's body in engagement with the seat belt when a collision involving the vehicle occurs. Additionally such belts have possessed an elongation which, in many situations,  
25 has allowed the head of an occupant to strike the steering wheel or the dash board when the occupant has been seated in a front seat.

Furthermore, the spooling out of the webbing  
30 material in the seat belt and the stretching of the seat belt have contributed to an increased duration of the unrestrained motion of the occupant. This in effect has delayed the onset of any effective restraint. This has meant that the motion of the occupant has had to be brought to a stop in a shorter  
35 time than would have been possible if the seat belt had not elongated. This has contributed to the production of undesirably high rates of motion on the occupant during the

restraint imposed by the seat belt on the movement of the occupant.

Even the use of inflatable seat belts of the types  
5 known in the prior art does not overcome all of the  
deficiencies and disadvantages discussed above. Prior  
attempts at eliminating these deficiencies and disadvantages  
with inflatable belts have included seat belts with a pair of  
inflatable sections within the belt and have additionally  
10 required the inflation of these sections to be accomplished  
by larger than desirable inflators. Previous attempts at  
producing satisfactory inflatable belts have also resulted in  
serious problems with storing the pair of inflatable sections  
in the vehicle and have required these inflatable sections to  
15 occupy areas which interfere with entrance and egress of the  
occupant respectively into and from the vehicle.

The deficiencies and disadvantages of prior art  
inflatable seat belts have also required the inflators to be  
20 positioned at the releasable coupling member and the retainer  
to be positioned at the sides of the seats. This duality of  
inflatable sections has caused many significant problems.  
One of these has been that the inflatable gases have had to  
pass through conduits located at the buckle attachment point  
25 of the belts that are in themselves releasable. This makes  
the belts and the inflator difficult to package and to  
operate.

It can be seen that the inflatable belts with dual  
30 inflatable sections have had to be attached to mechanisms  
which allow for variable lengths of the belts to be deployed  
due to variable sizes and positions of the occupants within  
the vehicle. This has required the inflator to be located at  
the buckle location with the aforementioned deficiencies or  
35 has required the heavy mass of the inflator to be contained  
within the inflatable sections of the seat belts.  
Furthermore, the duality of inflatable sections has required

additional inflators, squibs, wiring and the like to be used since both of the inflatable sections in the pair have had to be simultaneously inflated.

5           Inflatable seat belts known in the prior art have other significant deficiencies and disadvantages. For example, they do not adequately protect the occupant's neck and head in a side collision. Furthermore, they also do not adequately protect the occupant's lower extremities. This  
10 results from the fact that the front seat occupant's lower extremities tend to slide forward against the instrument panel at the time of the collision while the occupant in the rear seat tends to slide against the rear of the front seat. This has caused the occupants to incur injuries to the lower  
15 extremities.

The inflators associated with prior inflatable seat belts have included combustible materials and associated apparatus which have operated in an inefficient thermodynamic  
20 manner. This has required excessive amounts of pyrotechnic materials to be provided in the inflators so that the size and weight of the inflators have had to be increased to undesirable proportions. The amount of the pyrotechnic material required in the inflators of the prior art have been  
25 roughly between fifty percent (50%) to one hundred percent (100%) more than the pyrotechnic material used in the inflator of this invention. As a result, acceptable packaging of the inflatable belts and the inflator within a vehicle has been precluded.

30

The configuration and composition of the combustible materials used in existing inflators have also produced relatively slow inflation systems. These slow inflation systems, while useful for air bags, have not been  
35 useful for inflatable seat belts since such restraints have to deploy in less than one fourth of the time for the deployment of a typical air bag. This has been necessitated

by the fact that the inflatable belt and the inflatable side bag have to provide occupant protection from side impacts. Furthermore, the deceleration distance of a vehicle involved in a side collision and the time interval between the  
5 initiation of the side impact against the vehicle and the striking of the occupant against an interior vehicle surface are greatly reduced relative to the distance and time for a front impact.

10           The combustible materials for some of these systems have also required filters to collect the solid particulates that are produced. The solid particulates required to be filtered in such prior art systems have been excessive. other systems have been required to utilize pyrotechnic  
15 grains. These grains have been of such size that grain fracture and cracking have occurred and have caused variations in the combustion surface, thereby detrimentally affecting the burning rates within the grains and hence the inflation time.

20           Furthermore, when large grains have been utilized with slow burning rates, the variations in performance over the range of operating temperatures has been undesirably large. For example, assuming a 40-50 millisecond function  
25 time, the changes in the burning rate of the pyrotechnic material have caused the function time of the inflator to vary by approximately  $\pm 20\%$  when the temperature has been varied between 175°F and -65°F. This has resulted from changes in the burning rate of the pyrotechnic material with  
30 variations in the operating temperature. This considerable percentage change in the burning rate has produced a change in overall function time of approximately 15-20 milliseconds, an appreciable portion of the time available to an air bag to decelerate the movement of the occupant. The change in  
35 overall function has produced a resultant variation in protection.

## BRIEF DESCRIPTION OF THE INVENTION

This invention provides a system which overcomes the above disadvantages and deficiencies. It comprises a seat belt combining an inflatable belt portion disposed adjacent the occupant's chest, neck and head and an interconnected lap belt portion consisting of standard webbing which becomes tightened against the occupant's lap when the inflatable portion becomes inflated. This significant enhancement in restraint prevents the occupant in a front seat from sliding against the instrument panel or the steering wheel at the time of vehicular impact, thereby protecting against injury to the occupant's knees and lower extremities. It also prevents the occupant in a rear seat from sliding against the back of a front seat.

Furthermore, when inflated, the inflatable belt portion shortens in effective length and displaces away from the chest of the occupant to provide, in combination, pre-tensioning of the inflatable belt portion, load distribution and a support cushion for the head in frontal collision. Additionally, by passing the inflatable belt portion across the shoulder and alongside the head, the inflatable belt portion protects the occupant's neck and head from injury due to side impact.

The invention also provides an inflator which responds almost instantaneously when a collision involving the vehicle occurs. For example, the inflator provides for the inflation of the inflatable belt portion in approximately ten milliseconds (10 ms) after being triggered by the vehicle collision. This is enabled in part by the use of a small pressure volume of approximately two (2) cubic inches in the inflator of this invention. This small volume exhausts quickly into the inflatable belt portion of this invention. In contrast, inflators of the prior art have had a volume of approximately 10-40 cubic inches. Furthermore, the inflator of this invention has a high pressure which accelerates the



burn rate of the pyrotechnic material in the inflator of this invention.

The inflator of this invention is adapted for use  
5 with particles of a pyrotechnic material. Such particles  
cumulatively provide a large surface which enhances the  
burning rates of such particles. As a result, the small  
sizes of such particles provide for gas generation rates  
approximately ten (10) times greater than that of the  
10 inflators of the prior art. Furthermore, the relatively  
small amount of the pyrotechnic material in the inflator of  
this invention produces a minimal amount of any noxious by-  
products or noxious smells. The inflator is further  
advantageous in that all of the components in the inflator  
15 are disposed within a housing and in that a gas in the  
housing flows through a short opening directly into the  
inflatable belt portion to inflate the inflatable belt  
portion almost instantaneously after triggering by the  
vehicle collision.

20

When the particulate pyrotechnic material of this  
invention is subjected to the same temperature variation as  
given in the example above, i.e., -65° to +175°F, the overall  
time variation in the function time has been insignificant,  
25 particularly since the burning time of the propellant in the  
inflator of this invention is in the order of only 2-5  
milliseconds. This has provided for a much more consistent  
performance and for a significantly greater protection of the  
occupant when using the inflator of this invention than when  
30 using the inflators of the prior art.

In one embodiment of the inflator in the invention,  
pyrotechnic particles in a frangible container located within  
the inflator housing partially combust upon a vehicle  
35 collision. The partial combustion opens the container. The  
partially combusted particles thereafter combust almost  
instantaneously (e.g. 2-5 milliseconds) within the housing

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which also contains a gas. The resultant gas expansion provides for a communication between the housing and an opening normally isolated from the housing as by a rupturable diaphragm or a pop-off spring-loaded valve or by other such means known to those in the art. The gas flowing through the opening inflates a belt portion disposed diagonally across the occupant's chest and attached to a vehicle support structure (e.g. a pillar behind the occupant's seat), thereby protecting the occupant's chest, body, neck and head.

10

The inflatable belt portion of this invention is attached as by multiple stitching to webbing defining a lap belt portion. Some of this stitching becomes progressively, but not completely, detached to dissipate the forces imposed on the inflatable belt portion when the inflatable belt portion becomes inflated. The lap belt portion extends through an opening in a coupling member adjacent the inflatable belt portion and laterally across the occupant's lap.

20

The lap belt portion becomes tightened against the occupant's lap when the inflatable belt portion becomes inflated. The lap belt portion is removably attached as by the coupling member to a retainer at the inner side of the seat. When the coupling member is detached from the retainer, the lap belt portion becomes disposed (e.g. wound) on a retractor to dispose the inflatable belt portion near the outboard seat side between the support structure (e.g. the pillar behind the driver's seat) and the retractor. The occupant can then enter and exit the vehicle without encumbrance.

The inflatable belt portion can be enveloped within a cover made from a suitable material such as a polyester. The cover may be made from a single piece of material attached at its opposite ends as by stitching to define a cylinder enveloping the inflatable belt portion. The cover

stitching progressively separates as the inflatable belt portion becomes progressively inflated in the downward direction. The cover is advantageous in that it provides for a controlled inflation of the inflatable belt portion in a direction away from the inflator. It also minimizes degradation of the material forming the inflatable belt portion as from ultraviolet light and protects the inflatable belt portion from degradation as from chafing against the occupant. A stiffener may be disposed in the cover against the inflatable belt portion to prevent the inflatable belt portion from twisting. Alternatively, the cover may be made from a frangible fabric material designed to burst open as the inflatable belt portion is inflated.

15 A switch may be disposed in the retainer in an open position. When the coupling member is disposed in the retainer, the switch becomes closed. The switch is included in an electrical circuit which is operative to initiate the combustion of the pyrotechnic material, upon the occurrence of a collision involving the vehicle, when the switch is closed. In this way, the inflatable belt portion can become inflated upon the occurrence of a collision involving the vehicle only when the inflatable system of this invention is connected to protect the occupant's body. This is important in view of the cost of manufacturing an inflatable system and installing the inflatable system in a vehicle.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

30 Figure 1 is a sectional view of an inflator produced according to the invention, including a frangible container holding particles of a pyrotechnic material and including a housing enveloping the container and holding a gas, for producing thermodynamic energy for inflating an inflatable member such as an inflatable belt portion in a vehicle such as an automobile;

Figure 2 is a sectional view similar to that shown in Figure 1 but shows the inflator after the opening of the container as a result of a partial combustion of the particles of the pyrotechnic material in the container and  
5 further schematically shows the continued combustion of the pyrotechnic particles in the housing;

Figure 3 is a schematic fragmentary perspective view of a vehicle including a unitary belt, comprising an  
10 inflatable belt portion and a non-inflatable lap belt portion, adapted to restrain the movements of an occupant seated in the vehicle in the event of a collision involving the vehicle;

15 Figure 4 is a schematic fragmentary side elevational view of the vehicle and the occupant seated in the vehicle and shows the disposition of the inflatable belt portion and the lap belt portion after the inflation of the inflatable belt portion;

20

Figure 5 is a fragmentary perspective view of the unitary belt, including the inflatable belt portion and the lap belt portion, illustrating the attachment of the inflatable belt portion and the lap belt portion by an  
25 arrangement of stitches adapted for dissipating the stresses produced in the inflatable belt portion when the inflatable belt portion becomes inflated;

Figure 6 is a fragmentary sectional view taken  
30 substantially on the line 6-6 of Figure 5 and shows in additional detail the stitching attaching the inflatable belt portion and the lap belt portion to form the unitary belt, as well as the folding of the inflatable belt portion to produce a minimal stress on the inflatable belt portion when the  
35 inflatable belt portion becomes inflated;

Figure 7 is a fragmentary view showing in additional detail the stitching also shown in Figures 5 and 6 and illustrating the use of the seat belt stitching in the area where the inflatable belt portion remains folded even after inflation, this stitching being used to transmit loads from the inflatable belt portion to the lap belt portion;

Figure 8 is a front elevational view of a seated occupant and shows the unitary belt, including the inflatable belt portion and the lap belt portion, in solid lines with the inflatable belt portion and the lap belt portion restraining the occupant, while showing the inflatable belt portion in broken lines with the inflatable belt portion and the lap belt portion in a non-restraining stowed position;

Figure 9 is a sectional view of the inflatable belt portion and a cover enveloping the inflatable belt portion and is taken substantially on the line 9-9 of Figure 5.

20

#### DETAILED DESCRIPTION OF THE INVENTION

One embodiment of an apparatus (an inflator) for inflating an inflatable member such as an inflatable belt portion is generally indicated at 10 in Figures 1 and 2. Although the inflator 10 is described in this application as being particularly useful for inflating a member in a vehicle, it will be appreciated that the inflator may be useful in inflating members in other objects than vehicles.

In the embodiment of the inflator shown in the drawings, a housing 12 is provided. The housing 12 may be made from a material with a low thermal conductivity to serve as a pressure vessel for holding a gas, preferably a gas such as nitrogen, helium or argon. Argon is the preferred gas. All of these gases are preferably inert. The gas may be inserted into the housing 12 through a hollow pin 14 which

may be closed as by welding after the gas has been inserted into the housing.

The housing 12 may be crimped as at 16 to hold an insert 18 preferably having a low thermal conductivity. The housing 12 and the insert 18 may be formed from a metallic material preferably of a low thermal conductivity or from a material with an interior surface coating of a low thermal conductivity. The housing 12 and the insert 18 may also be formed from an epoxy, fiber glass, nylon or a number of other suitable materials having a low thermal conductivity, all which are well known in the art. A ring 19 is disposed in the housing 12 adjacent the crimp 16 to provide a seal for preventing gas leakage from the housing.

15

A switch 20 may be disposed in the insert 18. A diaphragm 22 may be pressed against the switch 20 when the pressure of the gas in the housing 12 exceeds a predetermined value. When the pressure of the gas in the housing 12 becomes less than such predetermined value, the diaphragm 22 becomes displaced from the switch 20. The switch 20 then becomes closed to illuminate a light on the instrument panel or display panel (not shown) at the front of the occupant compartment in the vehicle, thereby indicating that the inflator 10 is not operative. The operation of the switch 20 may provide a signal to associated electronic circuitry. This signal provides an indication that the inflator 10 is in a defective state. Such associated circuitry is believed to be known to a person of ordinary skill in the art.

30

A plug 26 may be made from a material having a low thermal conductivity. Preferably the plug 26 has the same composition as the material of the insert 18. Connector pins 24 extend into the plug 26. The connector pins 24 are connected electrically to a bridge wire 28. The bridge wire 28 is preferably coated or in direct juxtaposition with a first firing compound 28a which is selected to appropriately

interface electronically and thermally with the electro-thermal characteristics of the bridge wire 28 so as to provide the desired ignition of particles of a pyrotechnic material 30. The bridge wire 28 and the first firing  
5 compound 28a are believed to be known in the art.

The particles of the pyrotechnic material 30 are disposed within a frangible container 32 in juxtaposition to the first firing compound 28a. The plug 26a electrically  
10 isolates the connector pins 24, one from the other, to prevent electrical shorting. The burning time of the pyrotechnic material 30 may be between approximately one millisecond (1 ms.), and approximately thirty milliseconds (30 ms.) and is preferably between approximately two  
15 millisecond (2 ms.) and approximately five milliseconds (5 ms.), depending upon the application.

The combustible or pyrotechnic material 30 may constitute relatively small particles or granules with a size  
20 in the range of approximately 0.010 inches to approximately 0.060 inches. The particles may typically have physical dimensions approximately 0.050 inch in diameter and approximately 0.20 inch thick or physical dimensions which are roughly spherical and granular with a sixteen (16) mesh  
25 size.

Material 30 may illustratively constitute particles of a material designated as UPCO 302 or UPCO 718 by applicant's assignee of record in this application. The  
30 particles of the pyrotechnic material 30 may comprise a mixture of different sizes to control the time for the combustion of the combustible material. When used in the quantities required for the inflator 10, the material 30 has properties of providing by-products when partially combusted,  
35 or end products when fully combusted, that are environmentally safe and that do not produce offensive or noxious smells when used in the small quantities associated

with the inflator 10. The term "environmentally safe" as used herein is meant to indicate that the by-products and end products from the combustion of the pyrotechnic material 30 do not injure the occupant or damage the vehicle or the atmosphere.

The material designated as "UPCO 718" is particularly advantageous since it produces environmentally safe material when it combusts. The material designated as "UPCO 302" is advantageous because it generates a higher heat of combustion than the material "UPCO 718" but is disadvantageous in that it may generate some environmentally unsafe products such as carbon monoxide when it combusts. However, to counter this, a sufficient amount of oxygen can be included in the housing 12 to oxidize all of the carbon monoxide to carbon dioxide. Furthermore, an additional fuel can be included in the housing 12 to combust with any excessive oxygen in the housing 12 if such oxygen exists in the housing after the combustion of the pyrotechnic material from the container 32.

The housing 12 may be crimped as at 31 and a ring 34 may be provided at the crimp to seal the housing to a manifold 36. The ring 34 may be affixed to the housing 12 by well known means other than a crimp. The manifold 36 may be made from a material having a low thermal conductivity and may preferably correspond in composition to the insert 18 and the plug 26. A rupturable diaphragm 38 may be disposed across an opening 40 in the manifold 36 to isolate the opening from the housing 12 until the diaphragm becomes ruptured. It will be appreciated that other means than the diaphragm 38 may be used to isolate the housing 12 from the opening 40, and to provide a communication between the housing and the opening when the gas in the housing expands. For example, a spring-biased pop-off valve may be used instead of the diaphragm 38.



The opening 40 communicates with a conduit 42 extending from the manifold 36. The conduit 42 is preferably disposed fixedly in the manifold 36 as by a pin 44 or may be rotatably affixed as by a snap ring or by other means known 5 in the art. Alternatively, the conduit 42 may be capable of a relative rotation about its axis to assist in providing the most desirable position for inflating an inflatable belt portion 104 (Figure 4) as the inflatable belt portion passes over the occupant's body. The conduit 42 communicates with 10 the inflatable belt portion 104 (Figure 4). It will be appreciated that the conduit 42 may be omitted if the opening 40 is intended to communicate directly with the inflatable belt portion 104.

15 When a collision involving the vehicle occurs, a signal passes through the connector pins 24 to the bridge wire 28. This may be accomplished in a manner well known in the art. The bridge wire 28 then becomes heated to ignite the first firing compound 28a which in turn ignites particles 20 of the combustible material 30. The frangible container 32 becomes opened or ruptured by the heat generated from the combustion of the particles of the combustible material 30.

The rupture of the container 32 occurs after a 25 relatively short period of time such as approximately one millisecond (1 ms). At the end of this time, the particle size of the pyrotechnic material 30 has been diminished somewhat, but not significantly, by the partial combustion of the particles. After the rupture of the container 32, the 30 partially combusted particles of the pyrotechnic material 30 pass into the housing 12 where such particles continue to combust. This combustion occurs for a relatively short period of time such as approximately two to five milliseconds (2-5 ms). As shown schematically in Figure 2, the particles 35 of the pyrotechnic material travel in a direction away from the container toward the opening 40 and combust as they travel in this direction. This causes the particles of the

pyrotechnic material 32 to diminish in size as they travel from the container 32 toward the opening 40 .

The composition of the particles of the pyrotechnic material 30 and the combustion of the particles of the pyrotechnic material at progressive positions in the housing 12 offer certain important advantages. The pyrotechnic material 30, and particularly the "UPCO 718" material, combusts to produce by-products and end products which are not injurious to the environment or to the occupant. This is also true of the "UPCO 302" material when additional amounts of oxygen or fuel are disposed in the housing 12.

Furthermore, the combustion of the particles of the pyrotechnic material 30 in the housing 12 causes the heat generated by such combustion to be transferred directly and thermally to the molecules of the gas in the housing 12 without substantial contact with the housing 12, the end plug 18 and the manifold 36. The housing 12, the container 32, the end plug 18 and the manifold 36 present low thermal conductivity surfaces to interface with the heated gas, thereby causing the liberated heat from the combustion of the pyrotechnic combustion to be utilized effectively only to heat and expand such gas. Furthermore, the container 32 and the housing 12 do not absorb any significant amount of the generated heat because they are relatively thin and because the inflator 10 does not contain any filters which would absorb a significant amount of the thermal energy from the gas as the gas passes through the filters.

30

As previously indicated, the gas in the housing 12 is preferably nitrogen, helium or argon. All limit chemical reaction between the pyrotechnic material 30, or any by-products or end products resulting from the combustion of such pyrotechnic material, and such gas. Of the inert gases, argon is preferred because it has a low thermal conductivity. As a result, a substantial portion of the heat generated by

the combustion of the particles of the pyrotechnic material 30 is trapped within the molecules of the argon gas. This heat is used to raise the temperature of the molecules of the argon gas in the housing 12. It expands the argon gas in the 5 housing and increases the pressure of the argon gas against the diaphragm 38.

The frangible container 32 and the housing 12 also co-operate in maximizing the temperature increase of the gas 10 in the housing 12 as a result of the heat generated by the particulate combustion. The housing 12 and the container 32 are made from low thermal conductivity materials, at least on the surfaces in contact with the gas. Such materials may be ceramics, rubber coatings, polyethylene coatings and the 15 like. These materials have thermal conductivities of approximately 1 to 15 K/W(M.K.) as compared to a range of conductivities from 50 to 200 K/W (M.K.) when a relatively high thermal conductivity material such as steel or aluminum is used for the housing 12 and the container 32.

20 The housing 12 and the container 32 also do not absorb any significant amount of the generated heat because they are exposed to high temperatures only for relatively short periods of time of approximately ten milliseconds (10 25 ms) or less. This is in contrast to existing inflators which function at such elevated temperatures for approximately thirty to sixty milliseconds (30-60 ms). During such relatively extended periods of time, heat is transferred to the members forming such inflators.

30 When the gas has expanded sufficiently in the housing 12, the diaphragm 38 breaks and the gas expands through the opening 40 and the conduit 42. The conduit 42 may be optional. By eliminating the conduit 42, the heated 35 gas is transferred directly through the opening 40 to the inflatable belt portion 104. The area of the diaphragm 38 and the cross sectional areas of the opening 40 and the

conduit 42 may be selected to control the time for the rupture of the diaphragm 38 and the flow of the gas through the opening and the conduit into the inflatable belt portion 104. The particular composition of the pyrotechnic material 5 30 and the relative sizes of the different particles in such material also control the time within which the gas is to be heated within the container 32. Such particular composition accordingly controls the time for the gas to flow into the inflatable belt portion 104.

10

The gas flowing through the conduit 42 passes into an inflatable member such as the inflatable belt portion 104 which may be made from a suitable material such as nylon and may be included in a unitary belt generally indicated at 100 15 (Figures 3 and 4). Although the discussion in this specification is specifically directed to the inflatable belt portion 104, it will be appreciated that the inflator 10 may be used with other types of inflatable members, including air bags, than the inflatable belt portion 104.

20

The unitary belt 100 is adapted to be disposed in a vehicle generally indicated at 102. The unitary belt 100 is constructed to protect an occupant in the event of a collision involving the vehicle 102. As illustrated in 25 Figures 3 and 4, the inflatable belt portion 104 of the unitary belt 100 is attached at its upper end to a support structure such as a pillar 106 which is disposed at the side of the vehicle 102 and above a seat 108 which holds the occupant. The pillar 106 is disposed to the rear of a 30 vehicle door 110 through which the front seat occupant enters and exits. The support structure may alternately constitute any other suitable portion of the vehicle. For example, the support structure may constitute a flange on the inner surface of the roof portion when the inflatable belt portion 35 104 protects an occupant in the rear seat of the vehicle.

The inflator 10 shown in Figure 4 is preferably disposed at the upper end of the inflatable belt portion 104. When the inflatable belt portion 104 is attached to the pillar 106, this attachment may be at the upper end of the pillar 106. The inflatable belt portion 104 may be preferably integrated between a decorative fascia with the standard shoulder belt adjustment mechanism enabling the upper position of the inflatable belt portion to fit most favorably the full range of occupants. The inflatable belt portion 104 is preferably disposed above the occupant's shoulder and actually even above the occupant's neck and approximately at a horizontal level approximating the occupant's left cheek (if the occupant is the driver) or approximating the top of the occupant's head.

15

The inflatable belt portion 104 may be folded in a manner as shown in Figure 6. As shown in Figure 6, the inflatable belt portion 104 is provided with a pair of opposed wall portions 104a and 104b laterally displaced from each other. Each of the wall portions 104a and 104b extends in a zig-zag configuration from the lateral extremity of such wall portion to a position intermediate the lateral distance between the lateral extremities of such wall portions. This relationship enhances the speed at which the inflatable belt portion 104 can be inflated downwardly from the top of the inflatable belt portion. It also enhances the uniformity in the inflation downwardly of the inflatable belt portion 104.

A cover 105 (Figure 9) preferably envelopes the inflatable belt portion 104. The cover 105 may be formed from a suitable material such as a polyester and may be provided with a color matching the decor of the interior of the vehicle 102. The cover 105 may be formed from a single piece of material attached at its opposite ends as by stitching 109. The stitching 109 may be disposed to face the chest of the occupant so that it is not visible to other occupants in the vehicle. The cover 105 becomes separated

progressively from the inflatable belt portion 104 as the inflatable belt portion becomes inflated. A stiffener 107 is disposed within the cover 105 against the inflatable belt portion 104 to prevent the inflatable belt portion 104 from twisting so that is in a flattened configuration prior to inflation.

The cover 105 provides certain advantages. it prevents the inflatable belt portion 104 from becoming degraded as from ultraviolet light. It also prevents the inflatable belt portion 104 from becoming degraded as from chafing against the chest of the occupant. It additionally holds the inflatable belt portion 104 to a consistent initial minimal volume and holds the folds of the inflatable belt portion to provide a consistent unfolding of the belt portion. The stiffener 107 also assists in retaining the folds of the inflatable belt portion 104 to provide a consistent unfolding of the belt portion.

The inflatable belt portion 104 extends diagonally (at a transverse angle) downwardly to a position near, but above, the occupant's lap at the inner or inboard side of the occupant's seat 108. In this diagonal or transverse configuration, the inflatable belt portion 104 crosses the occupant's chest. At the lower position, the inflatable belt portion 104 is suitably connected to a standard seat belt webbing material which forms a lap belt portion 112. The lap belt portion 112 may be made from a suitable material such as nylon. The construction of the lap belt portion 112 may correspond to the construction of the lap belts now in use. The inflatable belt portion 104 and the lap belt portion 112 may be considered to form a unitary belt.

At a position near, but above, the occupant's lap, the lap belt portion 112 extends through a D-ring coupling member 116 (Figure 8). A D-ring coupling member such as the D-ring coupling member 116 is well known in the art. The

D-ring coupling member 116 has an opening 115 (Figure 5) through which the lap belt portion 112 extends to change the direction of the lap belt portion 112 from a downward and transverse direction to substantially a horizontal direction 5 (Figure 8) in which the lap belt portion extends across the occupant's lap. At its inner end, the lap belt portion 112 is attached to the D-ring coupling member 116 (Figure 3) which is removably coupled to a retainer 122 in the vehicle. The construction of the D-ring coupling member 116 and the 10 retainer 122 is well known in the art for use in vehicles such as automobiles now on the market.

The inflatable belt portion 104 becomes inflated downwardly from the top of the belt when the inflator 10 is 15 actuated. This is advantageous because it is desirable to exclude the mounting of the inflator 10 in undesirable locations such as the buckle and retractor locations due to their attendant gas and electrical connection deficiencies. Furthermore, the inflation of the inflatable belt portion 104 20 downwardly from the top of the inflatable belt portion facilitates protection initially of the head, neck and chest of the occupant. This results from the fact that an injury to the occupant's head, neck and chest can be life-ending but an injury to the occupant's lower extremities such as the 25 occupant's knees and ankles is generally at worst crippling but not life-ending. Furthermore, in the case of a side impact of the vehicle 102, the time available for interspacing the protective cushion between the head and the interior of the side of the vehicle in a collision against 30 the side of the vehicle is relatively short (e.g. 10-15 milliseconds). The downward inflation of the inflatable belt portion 104 from the top of the inflatable belt portion is particularly beneficial in such situations.

35 As will be seen from Figure 4, the inflatable belt portion 104, when inflated, protects the occupant's neck and head. This controls the occupant's head motion by providing

an inflated cushion which supports the occupant's head from beneath the chin and prevents the occupant's head from rotating violently in a forward direction. When the occupant's head rotates violently forward, as in the prior art, accompanied by a forward movement of the occupant's chest, the occupant's head may impinge against the dashboard or instrument panel or steering wheel (when the occupant is in a front seat) unless adequate restraint against this movement is provided as in this invention. Furthermore, the occupant's neck may be severely strained, as in the prior art, as a result of the violent jerk imparted downwardly to the neck at the time of the collision. It will be appreciated that the occupant's chest and legs are also protected by the inflatable belt portion of this invention. When the occupant is sitting in a rear seat, the occupant's neck and head are protected in this manner by the inflatable belt portion of this invention from moving against the rear of the front seat.

When the inflatable belt portion 104 becomes inflated, its effective length is shortened as the path length of the inflated material in the inflatable belt portion is forced outwardly. This in turn draws the webbing portion of the lap belt portion 112 through the D-ring portion of the coupling member 116 when the coupling member is coupled to the retainer 122. This causes the lap belt portion 112 to become tightened against the lap of the occupant.

The lap belt portion 112, when tightened by the inflation of the inflatable belt portion 104, restricts the movements of the occupant's lower torso. This inhibits the occupant's lower body from sliding forwardly and accordingly significantly mitigates the chance that the occupant's knees and feet will be injured. It also positions occupant's upper torso so that the occupant's head and chest can be most effectively restrained.



The amount of the pyrotechnic material 30 in the container 32 is so small and the inflation of the inflatable belt portion 104 is so fast that the temperature of the inflatable belt portion increases only a minimal amount. For example, the temperature rise of the inflatable belt portion 104 as a result of the inflation of such belt portion may be approximately only 7° Fahrenheit. This prevents the occupant from being burned such as sometimes occurs in the inflatable belts of the prior art.

10

As shown in Figures 5 and 6, the inflatable belt portion 104 is relatively narrow before inflation. This results from the zig-zag configuration of each of the wall portions 104a and 104b from the lateral extremity of such wall portion to a position intermediate the wall portions. This is shown in Figures 5 and 6. However, when the inflatable belt portion 104 becomes inflated, it expands so that the lateral distance between the wall portions 104a and 104b becomes considerably increased. This is best seen in Figures 7 and 8. This is advantageous since the unit force imposed upon the occupant's body at any position on the chest, neck and head of the occupant's body is considerably reduced by the significant increase in the area of contact of the inflatable belt portion 104 against the occupant's body.

25

The lap belt portion 112 is adapted to be coupled to a retractor 124 fixedly disposed in the vehicle near the floor of the vehicle. The retractor 124 may be constructed in a conventional manner well known in the art to dispose (e.g. wind) the lap belt portion 112 on the retractor or allow the unwinding of the lap belt portion from the retractor. Suitable retractors are used with lap belts in vehicles now on the market. For example, the retractor 124 may constitute a Webbing Velocity Sensitive Retractor (Part No. 501580-4031) manufactured and sold by Am-Safe of Phoenix, Arizona. This retractor is incorporated by reference in this application.

The retractor 124 prevents the lap belt portion 112 from being extended upon the occurrence of a collision involving the vehicle 102. Since the lap belt portion 112 cannot be extended at such a time, the inflation of the inflatable belt portion 104 produces a tightening of the lap belt portion 112 against the lap of the occupant. At the same time, the inflatable belt portion 104 becomes disposed adjacent to the occupant's head, neck and chest to substantially restrain movement of these portions of the occupant's body.

- When the coupling member 116 (Figures 3 and 5) is detached from the retainer 122 in a manner well known in the art, the retractor 124 causes the lap belt portion 104 to become disposed (e.g. wound) on the retractor. As a result, the inflatable belt portion 104 becomes disposed downwardly to a position adjacent, but to the rear of, the seat 108. This is shown in broken lines in Figure 8 and in solid lines in Figure 4. In the instance where the upper end of the inflatable belt portion 104 is attached to the pillar 106, the occupant is able to enter and exit the vehicle through the front door without any obstruction from any portion of the inflatable belt 104 since the pillar is to the rear of the front door.

25

As will be seen, the inflatable belt assembly 100 is advantageous because it can be retrofitted in a vehicle without having to adjust any of the components or sub-assemblies in the vehicle. The unitary belt 100 can be provided for the occupant of the driver's seat, the occupant of the other front seat and the occupants in the rear seats. The unitary belt 100 is provided as an integral assembly in each of these seats, in part because the inflator 10 for inflating the inflatable belt portion 104 is disposed in juxtaposition to such inflatable belt portion.

As will be appreciated from the above discussion, the inflatable belt portion 104 becomes inflated almost instantaneously after the occurrence of a collision involving the vehicle. As the inflation reaches the bottom of the inflatable belt portion 104, it exerts a large stress at the position of thickness discontinuity between the relatively thin section of the inflatable belt portion 104 and the thicker portion of the webbing of the standard seat belt construction as represented by the lap belt portion 112.

10 This webbing constitutes the material of the lap belt portion 112. The position of the thickness discontinuity is at the position where the inflatable belt portion 112 is attached to the lap belt portion 112.

15 The large stress at the position of the thickness discontinuity between the inflatable belt portion 104 and the lap belt portion 112 would tend to tear the thin material of the inflatable belt portion 104 and separate the inflatable belt portion 104 from the lap belt portion 112 if measures

20 were not provided to prevent this from occurring. If the inflatable belt portion 104 became fully separated from the inflatable belt portion 112, the effects of inflating the inflatable belt portion 104 would be lost from the standpoint of protecting the occupant.

25 Figures 5-7 show a stitching arrangement generally indicated at 130 for resolving the problem discussed in the previous paragraph. The stitching arrangement includes pluralities 132a, 132b, 132c, 132d and 132e of stitches 134.

30 The stitches 134 in each of the pluralities 132a, 132b, 132c, 132d and 132e are arranged in a saw-tooth or zig-zag pattern in which the stitches in such plurality extend along the overlapping lengths of the belt portions 104 and 112 and in which alternate ones of the pluralities 132a, 132b, 132c,

35 132d and 132e of the stitches 134 have first lateral positions and the other ones of the pluralities of the stitches have lateral positions different from the first

lateral positions. The pluralities 132a, 132b, 132c, 132d and 132e of the stitches 134 are displaced laterally from one another. Preferably each of the pluralities of stitches 132a, 132b, 132c, 132d and 132e of the stitches 134 is  
5 equally spaced in the lateral direction from the adjacent pluralities of stitches.

As best seen in Figure 5, the pluralities 132a, 132c and 132e of the stitches 134 have a greater length than  
10 the pluralities 132b and 132d of the stitches 134. The pluralities 132b and 132d of the stitches 134 are preferably disposed respectively between the pluralities 132a and 132c of the stitches 134 and between the pluralities 132c and 132e of the stitches 134. This arrangement is provided primarily  
15 to reduce any sudden rise in stress as the stress loads are transitioned from the thin material of the inflatable belt portion 104 to the thicker webbing of the lap belt portion 112. It will be appreciated that the pluralities 132a, 132b, 132c, 132d and 132e of the stitches 134 may have the same or  
20 variable lengths without affecting the scope of the invention.

At a position removed in the inflatable belt 104 from the pluralities 132a, 132b, 132c, 132d and 132e of the  
25 stitches 134, additional stitches 136 and 138 (Figures 6 and 7) are disposed laterally across the widths of the overlapping inflatable belt portion 104 and the lap belt portion 112 at spaced positions along the overlapping lengths of the inflatable belt portion and the lap belt portion.  
30 Additional stitches extend diagonally from each lateral edge of the stitches 136 to the other lateral edge of the stitches 138 to define a criss-cross pattern. Such diagonal stitches are indicated at 140 and 142. These stitches serve to  
35 transmit the loads carried by one lateral edge of the inflatable belt portion 104 along the lateral dimensions of the inflatable belt portion 104 and the lap belt portion 112 to the other lateral edge of the inflatable belt portion.

When the inflatable belt portion 104 becomes inflated downwardly from the upper position of such belt portion, the force produced on the thin inflatable cloth constituting the inflatable belt portion 104 at the bottom end of such inflatable belt portion acts upon progressive ones of the stitches 134 in each of the pluralities 132a, 132b, 132c, 132d and 132e. This action loads each stitch progressively to the point of separation and thereby provides for a separation of such stitch. This may be illustratively seen in Figure 7.

As the thin cloth at the lower end of the inflatable belt portion 104 becomes inflated and separated at the progressive ones of the stitches 134 in each of the pluralities 132a, 132b, 132c, 132d and 132e, the force is attenuated by the energy absorption of the breaking threads so much that the thin cloth is protected and remains fully intact and transmits the belt loads from the inflatable belt portion 104 to the lap belt portion 112. The zig-zag stitches are preferably at angles approximately  $45^\circ$  relative to the path of the inflatable belt portion 104 and are composed of threads whose breakage strength is such that every thread breaks sequentially, one after the other, so as to establish a maximum limit on the cloth load.

Inflatable belt assemblies are costly. It is accordingly desirable that the unitary belt 100 becomes inflated only when it is intended to be used. To accomplish this, a switch 141 (Figure 5) may be disposed in the coupling member 116 at a position where the coupling member is coupled to the retainer 122. The switch 141 is closed only when the coupling member 116 is coupled to the retainer 122. The switch 141 is connected in a circuit with the connector pins 24 in Figure 2. As a result, the inflator 10 is actuated to obtain a combustion of the pyrotechnic material 30 only when the switch 141 is closed. This prevents the inflatable belt portion 104 from being inflated except when the occupant

intends to obtain the protection provided by the unitary belt 100.

The system constituting this invention has certain  
5 important advantages in its individual sub-systems and in its assembly relationship. For example, the inflator 10 provides an almost instantaneous opening of the container 32 (Figures 1 and 2) and the heating of the gas in the housing 12 because of certain advantages in the inflator. These advantages  
10 include the composition of the pyrotechnic material 30, the formation of the pyrotechnic material as particles, the partial combustion of the particles of the pyrotechnic material in the container 32 and the combustion thereafter of the particles of the pyrotechnic material in the housing 12  
15 as such particles burn in juxtaposition in the housing to the gas with the low thermal conductivity. These advantages also include the minimal number of components in the inflator 10 and the thin and insulated walls of different components including the container 32, the housing 12 and the manifold  
20 36 and the materials from which these components are made.

Furthermore, since the pyrotechnic material 30 is in powder or granular form as distinguished from the larger grains used in some inflators in the prior art (20 times the  
25 size of the particles or grains of the pyrotechnic material of this invention), the combustion of the pyrotechnic material 30 can occur in a time considerably shorter than in the prior art. This fast combustion of the pyrotechnic material 30 also results in part from the small quantity of  
30 the pyrotechnic material in the container 32 and also in part from the relatively high pressure of about twelve thousand pounds per square inch (12,000 psi) at which combustion occurs, as compared to the prior art. The inflator 10 of this invention also provides for substantially uniform  
35 operating characteristics in the unitary belt 100 even with considerable changes in the ambient temperature. in the vicinity of the vehicle.

The unitary belt 100 also has certain important advantages. When the inflatable belt portion 104 becomes inflated, it protects the occupant's chest, neck and head. It also tightens the lap belt portion 112 against the 5 occupant across the occupant's lap. This provides additional protection for the occupant's lower extremities. When the occupant desires to enter or exit the occupant door 112, the coupling member 116 is detached from the retainer 122 and the lap belt portion 112 becomes disposed (e.g. wound) on the 10 retractor 124. This disposes the inflatable belt portion 104 substantially along the seat 108 at a position to the rear of the door 110 as shown in Figure 8.

The system constituting this invention also has 15 other advantages over the prior art. For example, the housing 12 is disposed adjacent the opening 40 and the optional conduit 42. This helps to minimize the time for the inflatable belt portion 104 to become inflated. It also minimizes the weight of the inflator 10 and the space 20 occupied by the inflator. The minimization in the weight of the inflator 10 and the space occupied by the inflator also minimizes the amount of the pyrotechnic material 30 in the inflator. As previously described, the pyrotechnic material is preferably in particulate or granular form. The 25 combustion of the pyrotechnic material 30 produces by-products and end products which-do not require a filter to be included in the inflator.

When the inflatable belt portion 104 becomes 30 inflated, it produces a large stress on the thin cloth defining the inflatable belt portion 104. This stress is absorbed by the separation of the inflatable belt portion 104 and the lap belt portion 112 at some of the stitches 134 in the pluralities 132a, 132b, 132c, 132d and 132e. Others of 35 the stitches 134 may remain intact as do the stitches 136, 138, 140 and 142. In this way, the inflatable belt portion 104 and the lap belt portion 112 remain attached without any

tearing of the cloth defining the inflatable belt portion 104.

The system of this invention is also advantageous 5 in the disposition of the cover 105 (Figure 9) in enveloping relationship to the inflatable belt portion 104 to protect the inflatable belt portion and control the inflation of the inflatable belt portion. The system is also advantageous in disposing the switch 141 in the retainer 122 to provide for 10 the operation of the system only when the switch is closed by the disposition of the coupling member 116 in the retainer.

Although this invention has been disclosed and illustrated with reference to particular embodiments, the 15 principles involved are susceptible for use in numerous other embodiments which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

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## I CLAIM:

1. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle,  
5 the vehicle having a support structure and having first and second retaining members,

a unitary belt including an inflatable belt portion and a lap belt portion,

the inflatable belt portion extending diagonally.  
10 across the chest of the occupant, the inflatable belt portion having first and second opposite ends and being constructed to be attached at the first end to the support structure in the vehicle,

the lap belt portion having first and second  
15 opposite ends and being attached at the first end to the second end of the inflatable belt portion and extending across the lap of the occupant from the second end of the inflatable belt portion, the second end of the lap belt portion having a coupling member for coupling to the first  
20 retaining member in the vehicle,

the lap belt portion having a second coupling member at a position near the inflatable belt portion for coupling to the second retaining member in the vehicle, and

means operatively coupled to the lap belt portion  
25 for extending the lap belt portion upwardly in the direction of the inflatable belt portion and for providing for a tightening of the lap belt portion against the lap of the occupant when the inflatable belt portion becomes inflated.

30 2. In a combination as set forth in claim 1, means disposed relative to the inflatable belt portion for providing an inflation of the inflatable belt portion when the vehicle is in a collision.

35 3. In a combination as set forth in claim 1 wherein

the inflatable belt portion extends substantially to the support structure in the vehicle to provide for the inflation of the inflatable belt portion at positions corresponding to the chest, the neck and the head of the  
5 occupant.

4. In a combination as set forth in claim 1  
wherein

the second retaining member includes a retractor  
10 constructed and disposed relative to the lap belt portion to dispose the lap belt portion on the retractor when the first coupling member is detached from the first retaining member and wherein the retractor is disposed relative to a seat in the vehicle for positioning the inflatable belt portion to  
15 facilitate entrance of the occupant into the vehicle and egress of the occupant from the vehicle when the first coupling member is detached from the first retaining member.

5. In a combination as set forth in claim 4,  
20 the vehicle including a seat for the occupant, means associated with the inflatable belt portion for inflating the inflatable belt portion when the vehicle is involved in a collision,

the inflatable belt portion extending substantially  
25 to the support structure to provide for the inflation of the inflatable belt portion to support the shoulder, the neck and the head of the occupant,

the support structure being disposed at one side of the seat and the second retaining member and the retractor  
30 being disposed at the same side of the seat as the support structure.

6. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle,  
35 the vehicle having support structure and having a seat for the occupant with an inboard side and an outboard side and having first retainer means at the inner side of the

occupant's seat and having second retainer means at the outer side of the occupant's seat,

a unitary belt including a lap belt portion and an inflatable belt portion,

5 the lap belt portion having first and second opposite ends and having a first coupling member at the first end for retention in the first retainer means and having a second coupling member near the second end for retention in the second retainer means, the second coupling member  
10 including an aperture constructed and disposed for passage of the lap belt portion through the aperture, and

the inflatable belt portion having a first end coupled to the second end of the lap belt portion and having a second end constructed for attachment to the support  
15 structure,

the inflatable belt portion being constructed to become inflated upon a collision involving the vehicle and to tighten the lap belt portion against the occupant upon the occurrence of such inflation.

20

7. In a combination as set forth in claim 6, means disposed in the inflation belt portion for storing a gas and for expanding the gas into the inflatable belt portion upon the occurrence of the collision involving  
25 the vehicle.

8. In a combination as set forth in claim 6, the vehicle having a floor,

the inflatable belt portion being constructed for  
30 attachment to the support structure at a position above the head of the occupant, and

the second retainer means being disposed near the floor of the vehicle and including a retractor to dispose the lap belt portion on the second retainer means and to provide  
35 a disposition of the inflatable belt portion near the occupant's seat when the first coupling member becomes

released from the first retainer and becomes disposed on the retractor.

9. In a combination as set forth in claim 6,  
5 the inflatable belt portion extending from the lap of the occupant at the inner side of the occupant's seat at a transverse angle toward the upper body portion of the occupant at the outer side of the occupant's seat.

10 10. In a combination as set forth in claim 9, the inflatable belt portion extending upwardly across the shoulder of the occupant and, upon the inflation of the inflatable belt portion, being disposed against one side of the neck and the head of the occupant to protect the  
15 occupant's neck and head.

11. In a combination as set forth in claim 10, means disposed relative to the inflatable belt portion for storing gas and for expanding the gas into the inflatable  
20 belt portion upon the collision of the vehicle,

the inflatable belt portion being constructed for attachment to the support structure at a position above the head of the occupant and

the second retainer means including a retractor  
25 constructed to dispose the lap belt portion on the retractor when the first coupling means becomes released from the first retainer means,

the second retainer means being disposed near the floor of the vehicle to provide a disposition of the  
30 inflatable belt portion near the seat when the first coupling member becomes released from the first retainer means and the lap belt portion becomes disposed on the retractor.

12. In a combination for protecting an occupant in  
35 a vehicle in the event of a collision of the vehicle, the vehicle having a seat for the occupant with an inboard side and an outboard side and having a support structure and

having a first retainer at the inboard side of the seat and having a second retainer at the outboard side of the seat, a unitary belt including a lap belt portion and an inflatable belt portion,

5 the lap belt portion being disposed to extend across the lap of the occupant and having a first coupling member at a first end for attachment to the first retainer, the lap belt portion having a second end opposite the first end,

10 the inflatable belt portion being attached to the lap belt portion at the second end of the lap belt portion, means disposed at the second end of the lap belt portion for coupling to the second retainer and for guiding the lap belt portion to the inflatable belt portion,

15 means disposed at the second end of the inflatable belt portion, for attaching the inflatable belt portion to the support structure, and

a retractor disposed relative to the lap belt portion near the second coupling member for minimizing slack  
20 in the lap belt portion upon the attachment of the first coupling member to the first retainer and for preventing the length of the lap belt portion from increasing when a force above a predetermined value is imposed on the lap belt portion for increasing the length of the lap belt across the  
25 lap of the occupant.

13. In a combination as set forth in claim 12, the inflatable belt portion extending from a position near the lap of the occupant at the inboard side of the seat upwardly  
30 across the chest of the occupant to the support structure in the vehicle.

14. In a combination as set forth in claim 12, means for providing an inflation of the inflatable belt  
35 portion upon the occurrence of a collision involving the vehicle,

the relative disposition between the inflatable belt portion and the lap belt portion providing for a tightening of the lap belt portion against the lap of the occupant when the inflatable belt portion becomes inflated.

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15. In a combination as set forth in claim 12, a force being imposed on the inflatable belt portion when the inflatable belt portion becomes inflated, means for interconnecting the lap belt portion and the inflatable belt portion in a relationship to provide for a dissipation in such interconnecting means, without a detachment between the lap belt portion and the inflatable belt portion, of the force imposed on the inflatable belt portion when the inflatable belt portion becomes inflated.

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16. In a combination as set forth in claim 13, the vehicle having a front door and a rear window and a pillar between the front door and the rear window, means for providing an inflation of the inflatable belt portion upon the occurrence of a collision involving the vehicle,

the relative disposition between the inflatable belt portion and the lap belt portion providing for a tightening of the lap belt portion against the lap of the occupant when the inflatable belt portion becomes inflated, and

means for interconnecting the lap belt portion and the inflatable belt portion in a relationship to provide for an absorption in such interconnecting means, without a detachment between the lap belt portion and the inflatable belt portion, of the force imposed in the inflatable belt portion when the inflatable belt portion becomes inflated, the support structure constituting a pillar between the front door and the rear window.

35

17. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle,

the vehicle having a support structure and having a seat with an inner side and an outside for holding the occupant,

a unitary belt including an inflatable belt portion and a lap belt portion,

5 the inflatable belt portion extending upwardly and transversely from the lap on one side of the occupant's body to the shoulder on the other side of the occupant's body,

the lap belt portion extending across the lap of the occupant,

10 first means for releasably coupling the lap belt portion to the vehicle at the inner side of the seat,

second means for guiding the lap belt portion at the inner side of the seat from a position extending across the lap of the occupant to a disposition in an upward

15 direction,

third means for interconnecting the lap belt portion and the inflatable belt portion at a position near the second means,

20 fourth means for coupling the lap belt portion to the vehicle at a position near the second means, and

fifth means for attaching the inflation belt portion to the support structure of the vehicle at a position above the shoulder of the occupant.

25 18. In a combination as set forth in claim 17, sixth means for retracting the lap belt portion to substantially eliminate any slack in the lap belt portion and for preventing extension of the lap belt portion after the lap belt portion has been attached to the inflatable belt  
30 portion.

19. In a combination as set forth in claim 17, the third means being constructed to absorb the force imposed on the inflatable belt portion during the  
35 inflation of the inflatable belt portion and before imposition of such force on the lap belt portion.

20. In a combination as set forth in claim 17, sixth means disposed relative to the inflatable belt portion for inflating such inflatable belt portion upon the occurrence of a collision involving the vehicle.

5

21. In a combination as set forth in claim 18, the third means being constructed to absorb the force imposed on the inflatable belt portion during the inflation of such inflatable belt portion and before  
10 imposition of such force on the lap belt portion, and seventh means disposed relative to the inflatable belt portion for inflating such inflatable belt portion upon the occurrence of a collision involving the vehicle.

15

22. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle, a unitary belt including an inflatable portion and a lap belt portion,

the inflatable belt portion being constructed to  
20 extend upwardly to protect the chest, neck and head of the occupant when inflated and to be attached to the vehicle at a first end of the inflatable belt,

the lap belt portion being constructed to extend across the lap of the occupant and to be attached at a second  
25 end to the vehicle,

first means for attaching a second end of the inflatable belt portion and a first end of the lap belt portion in an interrelationship providing for an absorption in the attaching means of force imposed on the lap belt  
30 portion as a result of the inflation of the inflatable belt portion, and

second means for guiding the lap belt portion from a disposition in the lap of the occupant to an upward direction for attachment by the first means of the first end  
35 of the lap belt portion to the second end of the inflatable belt means.



23. In a combination as set forth in claim 22, the lap belt portion being constructed to be attached at its first end to the vehicle and a retractor disposed at the first end of the lap belt portion for minimizing slack in the  
5 lap belt portion when the lap belt portion is disposed across the lap of the occupant and the first end of the lap belt portion is attached to the vehicle,

the lap belt portion being constructed to become locked in position when a force is imposed which would  
10 otherwise produce a slack in the lap belt portion as a result of a collision of the vehicle.

24. In a combination as set forth in claim 22, the second end of the lap belt portion being  
15 disposed and constructed to be decoupled from the vehicle, and

third means for producing, upon such detachment, a motion of the lap belt portion in a direction for displacing the lap belt portion from the lap of the occupant.  
20

25. In a combination as set forth in claim 24, the vehicle including a seat,

the inflatable belt portion and the lap belt portion being disposed and constructed to dispose the  
25 inflatable belt portion near the seat, upon the detachment of the second end of the lap belt portion from the vehicle, at a position providing for the exit of the occupant from the vehicle and the entrance of the occupant into the vehicle, without any obstruction from the inflatable belt portion or  
30 the lap belt portion.

26. In a combination as set forth in claim 22, third means for providing for an inflation of the inflatable belt portion upon the occurrence of a collision involving the  
35 vehicle.

27. In a combination as set forth in claim 25, the lap belt portion being constructed to be attached at its first end to the vehicle and a retractor disposed at the first end of the lap belt portion for minimizing any slack in the lap belt portion when the lap belt portion is disposed across the lap of the occupant and the first end of the lap belt portion is attached to the vehicle,

the lap belt portion being constructed to become locked in position when a force is imposed to produce a slack in the lap belt portion, and

means for providing for an inflation of the inflatable belt portion upon the occurrence of a collision involving the vehicle.

28. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle, a unitary belt including an inflatable belt portion and a lap belt portion,

the inflatable belt portion being constructed to extend upwardly to protect the chest, neck and head of the occupant when inflated and to be attached to the vehicle at a first end of the inflatable belt portion, the inflatable belt portion being made from a stitchable material,

the lap belt portion being constructed to extend across the lap of the occupant and to be coupled at a second end to the vehicle, the lap belt portion being made from a material stitchable into the lap belt portion and the inflatable belt portion,

means for stitching a second end of the inflatable belt portion and a first end of the lap belt portion in a relationship to provide for a coupling of the inflatable belt portion and the lap belt portion to form the unitary belt and, when the inflatable belt portion becomes inflated, to provide for a dissipation of a force exerted at the second end of the inflatable belt portion while at least some of the stitching means remains effective in coupling the inflatable

belt portion and the lap belt portion to form the unitary belt, and

means for guiding the lap belt portion from a disposition in the lap of the occupant to an upward direction  
5 for stitching by the stitching means of the lap belt portion to the inflatable belt portion.

29. In a combination as set forth in claim 28,  
means disposed at the first end of the inflatable belt  
10 portion for providing an inflation of the inflatable belt portion when a collision involving the vehicle occurs.

30. In a combination as set forth in claim 28,  
the lap belt portion being removably attached to  
15 the vehicle at the first end and including means at the second end for retracting the lap belt portion when the first end of the lap belt portion is decoupled from the vehicle.

31. In a combination as set forth in claim 28,  
20 the vehicle having a roof and a floor,  
the attachment of the inflatable belt portion to the vehicle being at a position near the roof of the vehicle and the attachment of the lap belt portion to the vehicle being at a position near the floor of the vehicle to provide  
25 for an entrance of the occupant into the vehicle, and an exit of the occupant from the vehicle, without any obstruction from the inflatable belt portion or the lap belt portion.

32. In a combination as set forth in claim 31,  
30 first means disposed at the first end of the inflatable belt portion for providing an inflation of the inflatable belt portion when a collision involving the vehicle occurs,  
the lap belt portion being removably attached to the vehicle at the second end of the lap belt portion and  
35 including means at the first end of the lap belt portion for retracting the lap belt portion when the lap belt portion is

detached from the vehicle at the second end of the lap belt portion.

33. In a combination as set forth in claim 29  
5 wherein

the first means includes a housing for a gas  
expansible upon becoming heated and includes particles of a  
pyrotechnic material disposed in a frangible container and  
wherein the frangible container is disposed in the housing  
10 and wherein the container is frangible upon the initiation of  
the combustion of the particles of the pyrotechnic material  
in the container and wherein the particles of the pyrotechnic  
material in the container are partially combusted when the  
container breaks and wherein such partially combusted  
15 particles of the pyrotechnic material combust in the housing  
to transfer heat to the gas stored in the housing for the  
expansion of the heated gas into the inflatable belt portion.

34. In a combination for protecting an occupant in  
20 a vehicle in the event of a collision involving the vehicle,  
an inflatable member for confining, when inflated,  
the disposition of the occupant in the vehicle,  
a frangible container for storing particles of a  
pyrotechnic material in the frangible container,  
25 a housing for storing a gas having properties of  
expanding when subjected to heat,  
first means for initiating the combustion of the  
particles of the pyrotechnic material upon the occurrence of  
a collision involving the vehicle to obtain the breaking of  
30 the frangible container after a partial combustion of the  
particles of the pyrotechnic material and the discharge of  
the partially combusted particles of the pyrotechnic material  
into the housing for a completion of the combustion of the  
particles of the pyrotechnic material in the housing and for  
35 the transfer of the resultant heat of combustion to the gas  
in the housing, and

second means responsive to the expansion of the gas in the housing for providing for a flow of the expanded gas from the housing through a controlled path.

- 5           35. In a combination as set forth in claim 34,  
the inflatable member constituting an inflatable  
belt portion,  
a lap belt portion coupled to the inflatable belt  
portion to define a unitary belt with the inflatable belt  
10 portion, and  
third means disposed in co-operative relationship  
with the inflatable belt portion and the lap belt portion and  
responsive to the inflation of the inflatable belt portion  
for providing for a tightening of the lap belt portion  
15 against the body of the occupant.

36. In a combination as set forth in claim 34,  
the controlled path including a conduit defining an  
opening for receiving the gas in the housing upon an  
20 expansion of the gas in the housing to provide for the  
inflation of the inflatable belt portion by such gas.

37. In a combination as set forth in claim 34  
wherein  
25 the second means includes a frangible diaphragm  
disposed between the housing and the controlled path and  
responsive to a particular pressure of the gas in the housing  
for becoming ruptured to provide for the flow of the gas in  
the housing through the controlled path.

- 30  
38. In a combination as set forth in claim 35,  
the controlled path including a conduit defining an  
opening for receiving the gas in the housing upon an  
expansion of the gas in the housing to provide for the  
35 inflation of the inflatable belt portion, and

the second means including a frangible diaphragm  
disposed between the housing and the conduit and responsive

to a particular pressure of the gas in the housing for becoming ruptured to provide for the flow of the gas in the housing through the opening in the conduit.

5           39. In a combination as set forth in claim 34, third means for providing for the insertion of the gas into the housing and for sealing the housing after such insertion.

10           40. In combination, an inflatable member, a frangible container, first means for storing particles of a pyrotechnic material in the frangible container,

15           a housing for storing a gas having properties of expanding when subjected to heat, second means for generating heat for instituting the combustion of the particles of the pyrotechnic material and for obtaining the breaking of the frangible container  
20 after a partial combustion of the particles of the pyrotechnic material and the discharge of the partially combusted particles of the pyrotechnic material into the housing for a completion of the combustion of the partially combusted particles of the pyrotechnic material in the  
25 housing and for the transfer of the resultant heat of combustion of the particles of the pyrotechnic material to the gas in the housing, and

third means responsive to the transfer of heat to the gas in the housing for inflating the inflatable member  
30 with such heated gas.

41. In a combination as set forth in claim 40 wherein

the second means includes a conduit having an  
35 opening extending from the housing, the conduit passing the heated gas into the inflatable member.

42. In a combination as set forth in claim 40  
wherein

the inflatable member constitutes an inflatable bag  
and wherein

5 the inflatable bag is disposed to extend across the  
chest of the occupant from the lap on one side of the  
occupant past the head on the other side of the occupant and  
wherein

the container, the second means, the housing and  
10 the third means are disposed to provide for the inflation of  
the inflatable bag downwardly from the head of the occupant  
toward the lap of the occupant.

43. In a combination as set forth in claim 40 wherein  
15 the inflatable member is disposed in a vehicle for  
protecting an occupant in the vehicle in the event of a  
collision involving the vehicle and wherein

the inflatable member includes an inflatable belt  
portion and wherein

20 a lap belt portion is connected to the inflatable  
belt portion and wherein third means are associated with the  
inflatable belt portion and the lap belt portion to provide  
for a tightening of the lap belt portion against the lap of  
the occupant in the vehicle when the inflatable belt portion  
25 becomes inflated and wherein

the inflatable belt portion and the lap belt  
portion define a unitary belt.

44. In a combination as set forth in claim 40  
30 wherein

the housing and the container are made from  
material having a low thermal conductivity.

45. In a combination as set forth in claim 44 for  
35 use in,

the inflatable member being disposed in a vehicle for protecting an occupant in the vehicle in the event of a collision involving the vehicle,

the third means including a conduit having an  
5 opening extending from the housing into the inflatable member,

the inflatable member including an inflatable bag,  
the inflatable belt portion being disposed to  
extend across the chest of the occupant from the lap on one  
10 side of the occupant past the head on the other side of the occupant and wherein

the container, the first means, the housing and the second means being disposed to provide for the inflation of the inflatable belt portion downwardly from the head of the  
15 occupant toward the lap of the occupant,

a lap belt portion being connected to the inflatable belt portion and defining a unitary belt with the inflatable belt portion, and

third means associated with the inflatable belt  
20 portion and the lap belt portion to provide for a tightening of the lap belt portion against the lap of the occupant in the vehicle when the inflatable belt portion becomes inflated upon the occurrence of a collision involving the vehicle.

25 46. In a combination,  
an inflatable member,  
a housing for holding a gas-expansible when heated,  
first means disposed in a co-operative relationship  
with the housing for holding particles of a material  
30 combustible to produce heat for expanding the gas in the housing, the first means being rupturable upon a partial combustion of the particles of the combustible material to provide for the continued combustion of the particles of the combustible material in the housing,

35 second means extending from the housing in pneumatically isolated relationship to the housing and constructed to become pneumatically communicative with the



housing upon the production of a predetermined pressure in the gas in the housing and to provide for an inflation of the inflatable member upon the pneumatic communication between the second means and the housing, and

5           third means for initiating a combustion of the particles of the combustible material in the first means.

47. In a combination as set forth in claim 46,  
the second means and the housing establishing a  
10 passage for the expanded gas into the second means from the housing, and

the inflatable member being disposed relative to the second means to receive the gas flowing through the second means for an inflation of the inflatable member.

15

48. In a combination as set forth in claim 46,  
means co-operative with the housing for indicating whether the pressure of the gas in the housing is within predetermined limits before the combustion of the particles  
20 of the combustible material in the first means.

49. In a combination as set forth in claim 46,  
means disposed in a co-operative relationship with the housing for providing for the introduction of the gas  
25 into the housing and for providing for the sealing of the gas in the housing after such introduction.

50. In a combination as set forth in claim 46,  
the gas in the housing constituting an inert gas.

30

51. In a combination as set forth in claim 47,  
means disposed in co-operative relationship with the housing for indicating whether the pressure of the gas in the housing is within predetermined limits before the combustion of the  
35 particles of the combustible material in the first means, and  
means disposed in co-operative relationship with the housing for providing for the introduction of the gas

into the housing and for providing for the sealing of the gas in the housing after such introduction

the gas in the housing constituting argon.

- 5           52. In a combination as set forth in claim 47,  
the housing and the first means being made from a material having a low thermal conductivity to minimize loss of heat produced by the combustion of the combustible material in the first means and the housing.

10

53. In combination,  
a housing for holding an expansible gas,  
a container disposed within the housing,  
particles of a pyrotechnic material disposed within  
15 the container, the particles having properties of combusting to produce by-products and end products which do not damage the environment and which do not injure the occupant,  
first means for initiating the combustion of the pyrotechnic material in the container,  
20 the gas in the housing being expansible upon the combustion of the particles of the pyrotechnic material,  
second means disposed in a co-operative relationship with the housing and defining a passage,  
third means responsive to the expansion of the gas  
25 in the housing for providing for a flow of the gas through the passage, and  
an inflatable member responsive to the flow of the gas through the passage to become inflated.

- 30           54. In a combination as set forth in claim 53,  
the container being frangible upon a partial combustion of the particles of the pyrotechnic material in the container and the partially combusted particles of the pyrotechnic material being further combustible in the housing  
35 after the breaking of the frangible container.

55. In a combination as set forth in claim 53,

the gas in the housing having a low thermal conductivity.

5 56. In a combination as set forth in claim 53, fourth means for providing for the insertion of the gas into the housing and for the sealing of the housing after such insertion.

10 57. In a combination as set forth in claim 53, the inflatable member being disposed in a vehicle to protect an occupant in the vehicle upon the occurrence of a collision involving the vehicle, the inflatable member including an inflatable belt portion,

15 a lap belt portion constructed and disposed to extend across the lap of the occupant,

the inflatable belt portion and the lap belt portion defining a unitary belt,

20 the inflatable belt portion being constructed and disposed to protect a portion of the occupant's body other than the occupant's lap, and

means for connecting the lap belt portion and the inflatable belt portion to provide for a tightening of the lap belt portion against the occupant's lap and the 25 disposition of the inflatable belt portion against such other portion of the occupant's body when the inflatable belt portion becomes inflated upon the occurrence of a collision involving the vehicle.

30 58. In a combination as set forth in claim 53, the inflatable member including an inflatable belt portion,

the inflatable belt portion being constructed and disposed to become inflated adjacent the chest, neck and head 35 of the occupant.

59. In a combination as set forth in claim 53,

the container being frangible upon a partial combustion of the particles of the pyrotechnic material in the container and the partially combusted particles of the pyrotechnic material being combustible in the housing after  
5 the rupture of the frangible container,

the gas in the housing being inert and having a low thermal conductivity, and

fourth means for providing for the insertion of the gas into the housing and for the sealing of the housing after  
10 such insertion.

60. In a combination as set forth in claim 59,  
the inflatable member being disposed in a vehicle for protecting an occupant upon an occurrence of a collision  
15 involving the vehicle,

the inflatable member including an inflatable belt portion,

a lap belt portion constructed and disposed to extend across the lap of the occupant,

20 the inflatable belt portion being constructed and disposed to protect a portion of the occupant's body other than the occupant's lap, and

fifth means for connecting the lap belt portion and the inflatable belt portion to define a unitary belt and to  
25 provide for a tightening of the lap belt portion against the occupant's lap in the vehicle and the disposition of the inflatable belt portion against such other portion of the occupant's body when the inflatable belt portion becomes inflated upon the occurrence of a collision involving the  
30 vehicle.

61. In a combination as set forth in claim 53,  
means disposed in the housing for indicating when the pressure of the gas in the housing falls below a  
35 predetermined level.

62. In a combination for protecting an occupant in a seat in the event of a vehicular collision, the seat having inboard and outboard sides,

5 a vehicle including a seat and a support structure,  
a unitary belt including an inflatable belt portion  
and a lap belt portion,

the inflatable belt portion extending downwardly from the support structure across the chest of the occupant to the inboard side of the seat, the inflatable belt portion  
10 having an upper end and a lower end,

the lap belt portion being attached to the inflatable belt portion at the lower end of the inflatable belt portion to define the unitary belt with the inflatable belt portion and extending across the lap of the occupant  
15 from the inboard side of the seat to the outboard side of the seat,

first means operatively coupled to the inflatable belt portion for inflating the inflatable belt portion upon the occurrence of a collision involving the vehicle, and

20 second means associated with the lap belt portion for retaining the lap belt portion against the lap of the occupant when a collision involving the vehicle occurs and the inflatable belt portion becomes inflated.

25 63. In a combination as set forth in claim 62,  
the second means including a frangible container holding particles of a pyrotechnic material combustible when a collision involving the vehicle occurs,

a housing,  
30 the frangible container being disposed in the housing to become opened upon the initiation of the combustion of the particles of a pyrotechnic material in the frangible container and to provide for the completion of the combustion of the particles of the pyrotechnic material in  
35 the housing,

there being in the housing a gas which becomes heated upon the combustion of the particles of the pyrotechnic material in the housing, and

third means responsive to the heating of the gas in the housing for providing for the passage of the heated gas into the inflatable belt portion for inflating the inflatable belt portion.

64. In a combination as set forth in claim 62, the vehicle having a floor, the second means including a retractor disposed in the vehicle near the floor of the vehicle and operative to provide for an initial extension of the lap belt portion across the lap of the occupant and thereafter operative to prevent an extension of the lap belt portion, thereby to prevent the lap belt portion from becoming extended upon the occurrence of a collision involving the vehicle and to cause the lap belt portion to become tightened against the lap of the occupant when the inflatable belt portion becomes inflated.

65. In a combination as set forth in claim 64, a retainer in the vehicle at the inboard side of the seat, and a coupling member disposed at the end of the lap belt portion and attachable to the retainer to retain the lap belt portion across the lap of the occupant, the retractor being disposed and operable to dispose the lap belt portion on the retractor upon a detachment of the coupling member from the retainer, thereby to provide for an entrance of the occupant into the vehicle, and an exit of the occupant from the vehicle, without any obstruction from the inflatable belt portion.

66. In a combination as set forth in claim 65, the second means including a frangible container holding the particles of the pyrotechnic material, the

pyrotechnic material being combustible when a collision involving the vehicle occurs,

a housing,

the frangible container being disposed in the  
5 housing and being rupturable upon the initiation of the combustion of the particles of the pyrotechnic material in the frangible container and to provide for the completion of the combustion of the particles of the pyrotechnic material in the housing,

10 there being in the housing a gas which becomes heated upon the combustion of the particles of the pyrotechnic material in the housing, and

third means responsive to the heating of the gas in the housing for passing the heated gas into the inflatable  
15 belt portion for inflating the inflatable belt portion.

67. In a combination for protecting an occupant in the event of a vehicular collision,

a vehicle including support structure, a seat  
20 having an inboard side and an outboard side, a retainer near the inboard side of the seat and a retractor near the outboard side of the seat,

a unitary belt including an inflatable belt portion and a lap belt portion,

25 the inflatable belt portion being attached to the support structure above the chest of the occupant in the occupant's seat and extending downwardly in a transverse direction across the occupant's chest to a position approaching the occupant's lap,

30 the lap belt portion being attached to the inflatable belt portion at a position near the bottom of the inflatable belt portion and extending across the occupant's lap to the inboard side of the occupant's lap,

first and second coupling means on the lap belt  
35 portion for respective attachment to the retainer and the retractor, and

inflating means operatively coupled to the inflatable belt portion for inflating the inflatable belt portion when a collision involving the vehicle occurs.

5                   68. In a combination as set forth in claim 67 wherein

the inflatable belt portion extends across the neck and against the cheek of the occupant when inflated to protect the chest, neck and head of the occupant upon the  
10 occurrence of a collision involving the vehicle.

69. In a combination as set forth in claim 67, the vehicle having a floor,  
15 the retractor being disposed near the floor at a position near the seat and constructed to dispose the lap belt portion on the retractor when the coupling means is released from the first retainer so as to provide for an unobstructed entrance of the occupant into the vehicle and an  
20 unobstructed exit of the occupant from the vehicle.

70. In a combination as set forth in claim 67, the inflating means being disposed relative to the inflatable belt means to inflate the inflatable belt means  
25 upon the occurrence of a collision involving the vehicle, the inflating means including particles of a material combustible to produce by-products and end products not injurious to the occupant or damaging to the atmosphere.

30                   71. In combination as set forth in claim 70, the inflatable belt portion extending across the neck and against the cheek of the occupant when inflated to protect the chest, neck and head of the occupant, the second retainer including a retractor disposed  
35 near the floor at a position near the seat and constructed to dispose the lap belt portion on the retractor when the first coupling means is released from the first retainer so as to



provide for an unobstructed entrance of the occupant into the vehicle and an unobstructed exit of the occupant from the vehicle.

5           72. In a combination for protecting an occupant in the event of a vehicular collision,

          a vehicle including a floor, a support structure, a seat having inboard and outboard sides and a retainer disposed near the inboard side of the seat and near the floor  
10 of the vehicle,

          a unitary belt including an inflatable belt portion and a lap belt portion,

          the inflatable belt portion being attached to the support structure at a position above the chest of the  
15 occupant when the occupant is seated in the seat, the inflatable belt portion extending downwardly and transversely across the chest of the occupant,

          the lap belt portion extending across the lap of the occupant from the outboard side of the seat to the  
20 inboard side of the seat and having coupling means for attachment to the retainer,

          first means disposed relative to the inflatable belt portion for inflating the inflatable belt portion upon the occurrence of a collision involving the vehicle, and

25           second means for attaching the inflatable belt portion and the lap belt portion in a relationship to provide for the absorption by the second means of the force produced on the inflatable belt portion, as a result of the inflation of the inflatable belt portion, without producing a  
30 detachment of the lap belt portion from the inflatable belt portion.

73. In a combination as set forth in claim 72,

          third means for redirecting the lap belt portion at  
35 the outboard side of the seat from a direction along the lap of the occupant to a direction corresponding to the transverse direction of the inflatable belt portion to

provide for an attachment of the lap belt portion to the inflatable belt portion by the second means.

74. In a combination as set forth in claim 72,  
5 a retractor disposed in the vehicle on the outboard side of the seat near the vehicle floor and constructed to dispose the lap belt portion on the retractor when the coupling means is detached from the retainer, thereby providing for the entrance of the occupant into the vehicle,  
10 and the exit of the occupant from the vehicle, without any obstruction from the inflatable belt portion.

75. In a combination as set forth in claim 72,  
the second means including pluralities of threads  
15 extending through the inflatable belt portion and the lap belt portion with such portions disposed in an overlapping relationship to each other.

76. In a combination as set forth in claim 74,  
20 the inflatable belt portion and the lap belt portion being disposed in an overlapping relationship along portions of their lengths,

the threads in each of the pluralities being disposed in a zig-zag relationship along the overlapping  
25 portions of the inflatable and lap belt portions,

the second means also including additional threads extending laterally between the lateral extremities of the inflatable belt portion and the lap belt portion in the overlapping portions of the inflatable belt portion and the  
30 lap belt portion and additionally including threads extending diagonally between the opposite lateral extremities of the overlapping portions of the inflatable and lap belt portions in communication with the additional threads.

35 77. In a combination as set forth in claim 76,  
the vehicle including a retractor disposed near the floor at a position near the seat and constructed to dispose

the lap belt portion on the retractor when the coupling means is released from the first retainer so as to provide for an unobstructed entrance of the occupant into the vehicle and an unobstructed exit of the occupant from the vehicle,

5           third means for redirecting the lap belt portion at the outboard side of the lap belt portion from a direction along the lap of the occupant to the transverse direction of the inflatable belt portion to provide for an attachment of the lap belt portion to the inflatable belt portion by the  
10 second means,

          a retractor disposed in the vehicle on the outboard side of the seat near the floor of the vehicle and constructed to dispose the lap belt portion on the retractor when the coupling means is detached from the retainer,  
15 thereby providing for the unobstructed entrance of the occupant into the vehicle, and the unobstructed exit of the occupant from the vehicle,

          the second means including pluralities of threads extending through the inflatable belt portion and the lap  
20 belt portion in the overlapping distance of the lap belt portion and the inflatable belt portion.

78. In a combination for protecting an occupant, a vehicle including a seat,  
25           an inflator including a frangible container and including particles of a pyrotechnic material in the container and including a housing for holding a gas, the frangible container being disposed relative to the housing for communication with the housing when the container breaks  
30 to obtain the disposition of the particles of the pyrotechnic material in the housing after the opening of the frangible container and before the completion of the combustion of the particles of the pyrotechnic material in the container,  
          means disposed relative to the housing for  
35 providing for the flow of the gas from the housing upon the expansion of the gas as a result of the heat generated by a combustion of the particles of the pyrotechnic material in

the housing upon the occurrence of a collision involving the vehicle, and

an inflatable member disposed relative to the flow of the gas from the housing for inflation by such gas to  
5 protect the occupant in the seat.

79. In a combination as set forth in claim 78,  
means disposed relative to the housing for  
preventing the gas from flowing from the housing to the  
10 inflatable member, such means being actuated by the force of  
the gas in the housing to establish the flow of the gas from  
the housing to the inflatable member.

80. In a combination as set forth in claim 78,  
15 means responsive to a collision involving the  
vehicle for igniting the particles of the pyrotechnic  
material in the container.

81. In a combination as set forth in claim 78,  
20 the inflatable member being constructed and  
disposed relative to the occupant in the seat to become  
inflated through a distance protecting the occupant's head,  
neck, shoulder and chest when a collision involving the  
vehicle occurs.

82. In a combination as set forth in claim 78  
25 wherein  
the isolating means includes a rupturable diaphragm  
and wherein  
30 a conduit is disposed between the housing and the  
inflatable member to pass the gas from the housing to the  
inflatable member when the diaphragm ruptures.

83. In a combination as set forth in claim 78  
35 wherein  
the gas is inert.

84. In a combination as set forth in claim 79,  
means responsive to a collision involving the vehicle for  
igniting the pyrotechnic material in the container,  
the inflatable member being constructed and  
5 disposed relative to the occupant in the seat to become  
inflated through a distance protecting the occupant's head,  
neck, shoulder and chest when a collision involving the  
vehicle occurs,  
the pyrotechnic material constituting particles of  
10 a material combustible to provide by-products and end  
products which do not injure the occupant or damage the  
atmosphere, the gas being argon.
85. In a combination for protecting an occupant, a  
15 vehicle including a seat,  
a frangible container,  
particles of a pyrotechnic material in the  
container,  
a housing holding a gas and disposed in  
20 communicable relationship with the container to receive the  
particles of the pyrotechnic material before the full  
combustion of the particles of the pyrotechnic material and  
to provide for the continued combustion of the particles of  
the pyrotechnic material in the housing when the container  
25 breaks,  
means for initiating a combustion of the particles  
of the pyrotechnic material when a collision involving the  
vehicle occurs,  
a conduit disposed in communicable relationship  
30 with the housing for receiving and passing the heated gas in  
the housing,  
a diaphragm disposed between the housing and the  
conduit for isolating the housing from the conduit and  
rupturable by the heated gas to provide a communication  
35 between the housing and the conduit, and  
an inflatable bag responsive to the gas passing  
through the conduit to become inflated, the inflatable bag

being disposed relative to the seat to protect the occupant in the seat when the bag becomes inflated.

86. In a combination as set forth in claim 85  
5 wherein

the conduit is disposed in contiguous relationship to the housing and is separated from the housing only by the diaphragm.

87. In a combination as set forth in claim 85  
10 wherein

— the gas is an inert gas selected from the group consisting of nitrogen, helium and argon.

88. In a combination as set forth in claim 85,  
15 the inflatable bag including an inflatable belt portion including a pair of oppositely disposed wall portions each extending in a zig-zag configuration to a position intermediate the lateral distance between the oppositely  
20 disposed wall portions.

89. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle,  
an inflatable bag including a pair of oppositely  
25 disposed walls, each individual one of the walls extending in a zig-zag configuration from the lateral extremity of such wall to a position intermediate the lateral distance between the oppositely disposed walls, and  
inflating means for inflating the inflatable bag.

30

90. In a combination as set forth in claim 89, the inflatable bag being disposed in a direction having a vertical component to define a top to the bag, and  
the inflating means being disposed relative to the  
35 inflatable bag to inflate the inflatable bag from the top of the inflatable bag.

91. In a combination as set forth in claim 89, the inflatable bag including an inflatable belt portion disposed in a direction having a vertical component to define a top to the inflatable belt portion,

5 a unitary belt including the inflatable belt portion and a lap belt portion disposed below the inflatable belt portion, and

the inflating means being disposed relative to the inflatable belt portion for inflating the inflatable belt  
10 portion from the top of the inflatable belt portion in a direction toward the lap belt portion.

92. In a combination as set forth in claim 89, the inflatable bag including an inflatable belt  
15 portion,

the inflatable belt portion being disposed in a direction having a vertical component to define a top to the inflatable belt portion,

a unitary belt including the inflatable belt  
20 portion and a lap belt portion disposed below the inflatable belt portion,

the inflating means being disposed relative to the inflatable belt portion to inflate the inflatable belt  
portion from the top of the inflatable belt portion in a  
25 direction downwardly toward the lap belt portion,

the lap belt portion being disposed relative to the lap belt portion to confine the lower portion of the occupant's body when the inflatable belt portion becomes inflated.

30

93. In a combination for protecting an occupant in a vehicle in the event of a collision involving the vehicle, an inflatable belt portion disposed in a direction having a vertical component to define a top to the inflatable  
35 belt portion,

inflating means for inflating the inflatable belt portion from the top of the inflatable belt portion, and

a lap belt portion operatively coupled to the lap belt portion at the bottom of the inflatable belt portion, the inflatable belt portion and the lap belt portion defining a unitary belt.

5

94. In a combination as set forth in claim 93, the lap belt portion extending across the lap of the occupant and being disposed relative to the inflatable belt portion to become tightened against the body of the occupant when the inflatable belt portion becomes inflated.

95. In a combination as set forth in claim 93, means for attaching the bottom of the inflatable belt portion and the lap belt portion to provide for a partial, but not a complete, detachment of the lap belt portion from the inflatable belt portion when the inflatable belt portion becomes inflated.

96. In a combination as set forth in claim 94, the inflating means including a housing with gas in the housing and including particles of a pyrotechnic material disposed in an isolated relationship to the housing before the initiation of combustion of the particles of the pyrotechnic material and movable into the housing after a partial combustion of the particles of the pyrotechnic material, and

means for initiating the combustion of the particles of the pyrotechnic material upon the occurrence of a collision involving the vehicle.

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97. In a combination as set forth in claim 94, means for attaching the bottom of the inflatable belt portion and the lap belt portion to provide for a partial, but not a complete, detachment of the lap belt portion from the inflatable belt portion when the inflatable belt portion becomes inflated,



the inflating means including a housing with gas in the housing and including particles of a pyrotechnic material disposed in an isolated relationship to the housing before the initiation of the combustion of the particles of the  
5 pyrotechnic material and movable into the housing after a partial combustion of the particles of the pyrotechnic material, and

means for initiating the combustion of the particles of the pyrotechnic material upon the occurrence of  
10 a collision involving the vehicle.

98. In a combination for protecting an occupant, a vehicle including a retainer and a switch disposed in the retainer and having open and closed  
15 relationships and normally disposed in the open relationship, an inflatable belt portion,

a lap belt portion attached to the inflatable belt portion and extending across the lap of the occupant for fixedly retaining the lower body portion of the occupant when  
20 the inflatable belt portion becomes inflated,

the inflatable belt portion and the lap belt portion defining a unitary belt,

an inflator for inflating the inflatable belt portion, the inflator including particles of a pyrotechnic  
25 material and a gas and electrical circuitry for igniting the particles of the pyrotechnic material to obtain the combustion of the particles of the pyrotechnic material and for expanding the gas as a result of the heat generated by the combustion of the particles of the pyrotechnic material,

30 electrical circuitry including the switch, and a coupling member extending from the lap belt portion for coupling to the retainer to close the switch and to energize the circuitry for igniting the particles of the pyrotechnic material upon the closure of the switch and upon  
35 the occurrence of a collision involving the vehicle.

99. In a combination as set forth in claim 98,

the vehicle including a support structure and including a seat, and

the inflatable belt means being attached to the support structure and extending relative to the occupant in  
5 the seat to protect the chest, neck, shoulder and head of the occupant when the inflatable belt be comes inflated.

100. In a combination as set forth in claim 99,  
the seat having inboard and outboard sides, a  
10 retractor disposed in the vehicle at the outboard side of the seat,

the retractor being disposed on the outboard side of the seat to dispose the lap belt portion on the retractor, and to dispose the inflatable belt portion between the  
15 support structure and the retractor, when the coupling member is uncoupled from the retainer.

101. In a combination as set forth in claim 98,  
the inflator including a housing for holding  
20 molecules of the gas and for receiving the particles of the pyrotechnic material after the partial combustion of such particles to provide for the continued combustion of such partially combusted particles in the housing and the transfer of the resultant heat of combustion directly to the gas to  
25 expand the space occupied by such gas molecules.

102. In a combination as set forth in claim 34,  
the housing also including gaseous components for completing the combustion of the pyrotechnic material and by-  
30 products of the combustion of the pyrotechnic material when the pyrotechnic material becomes disposed in the housing.

103. In a combination as set forth in claim 40,  
the housing also including gaseous components for  
35 completing the combustion of the pyrotechnic material and by-products of the combustion of the pyrotechnic material when the pyrotechnic material becomes disposed in the housing,

104. In a combination as set forth in claim 53,  
the housing also including gaseous components for  
completing the combustion of the pyrotechnic material and by-  
products of the combustion of the pyrotechnic material when  
the pyrotechnic material becomes disposed in the housing.

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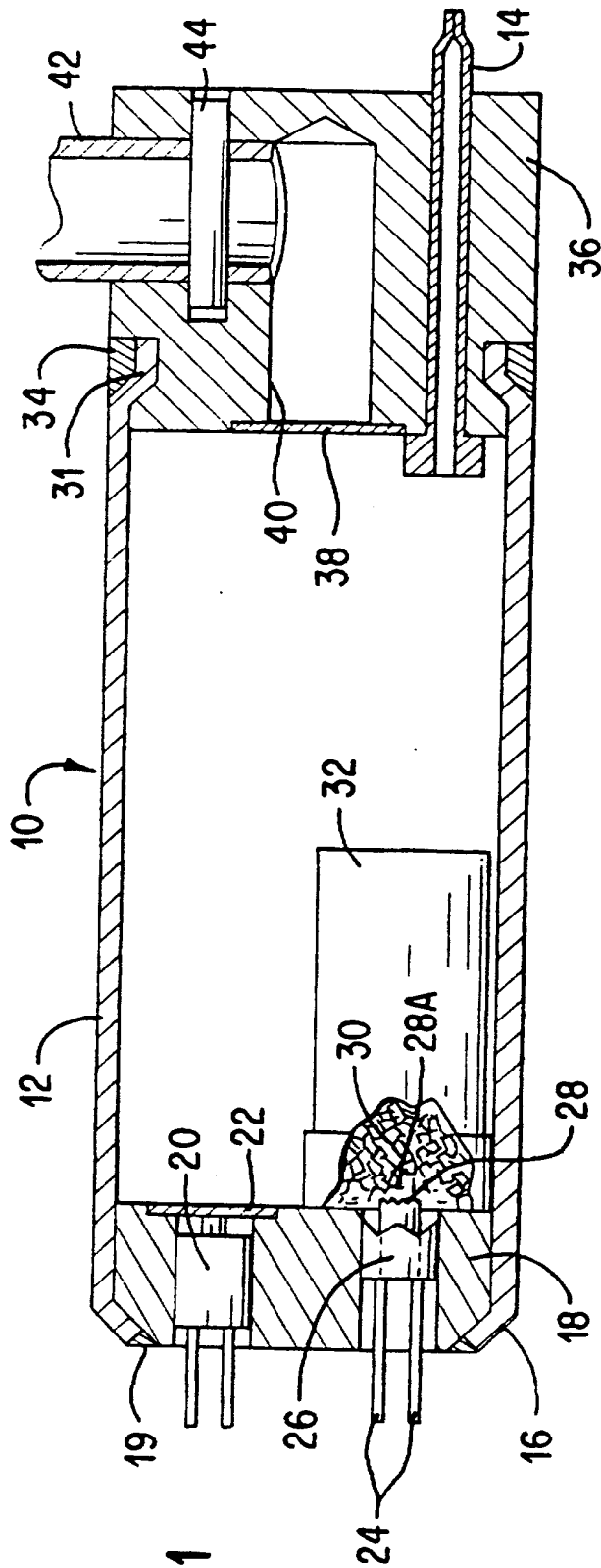


FIG. 1

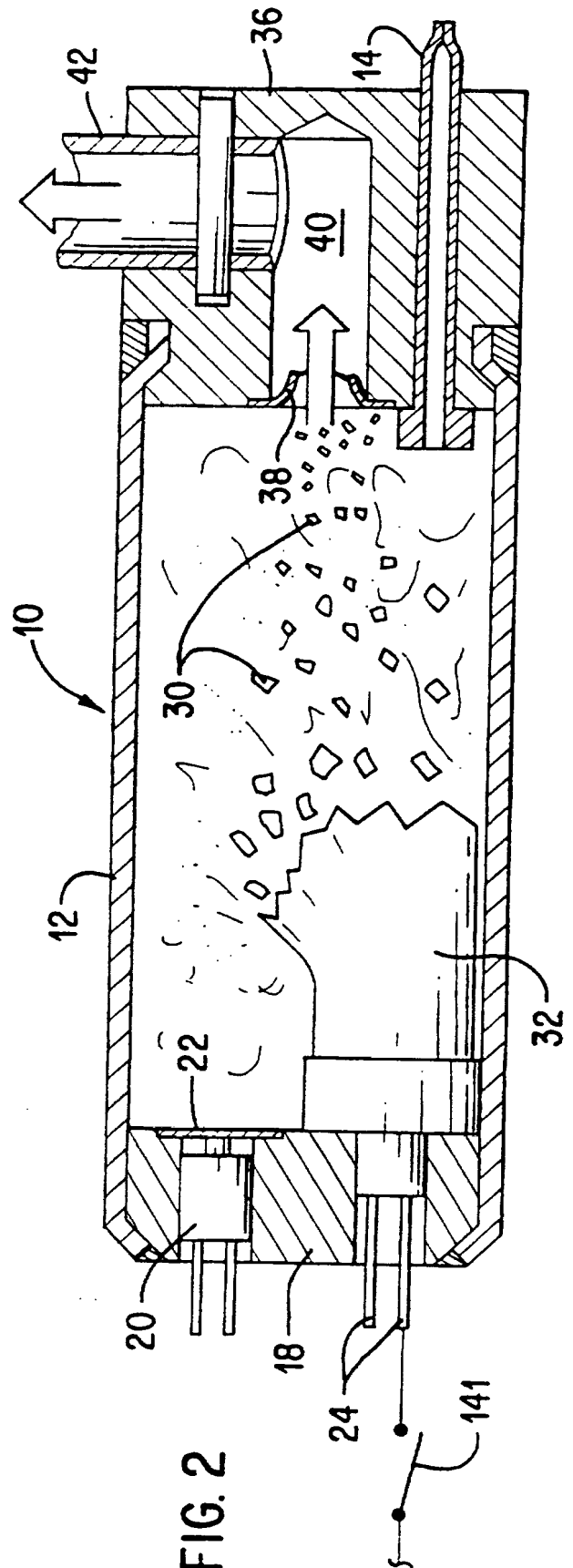


FIG. 2

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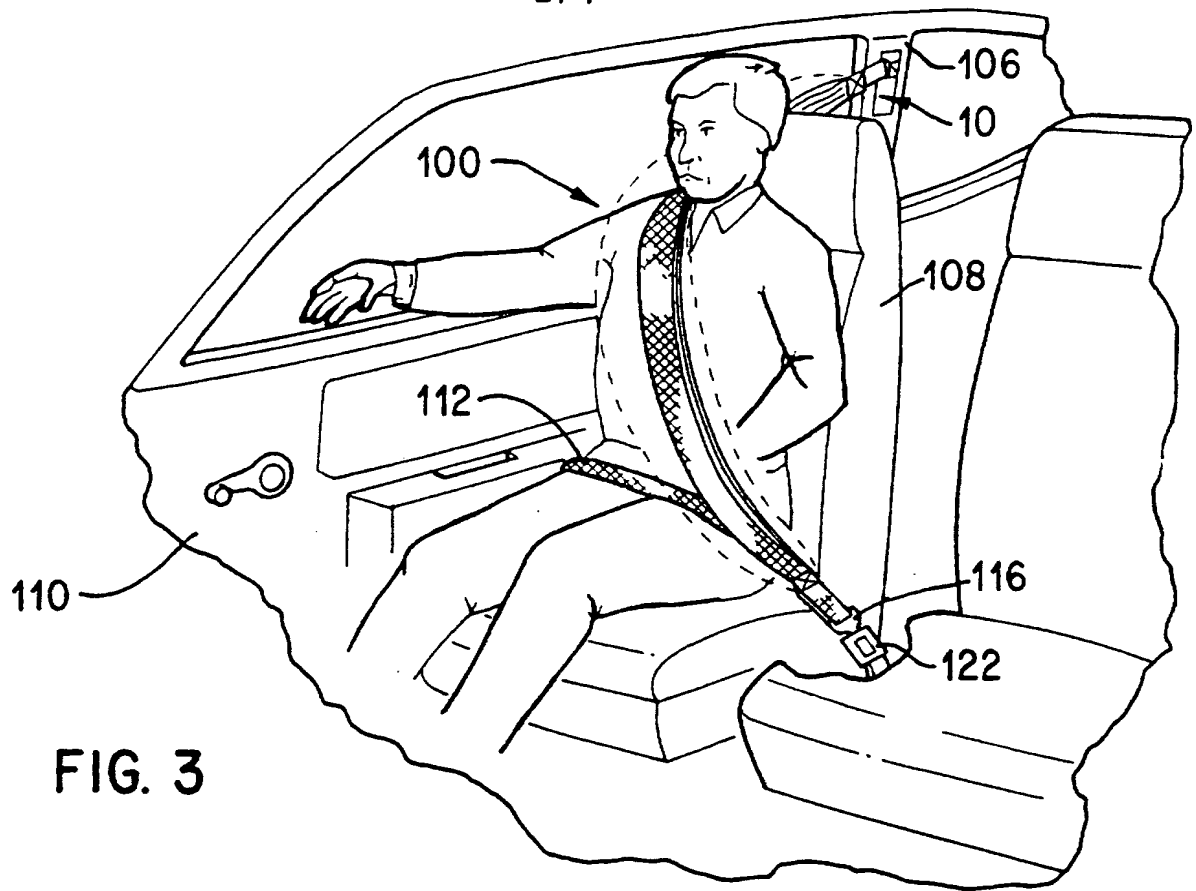


FIG. 3

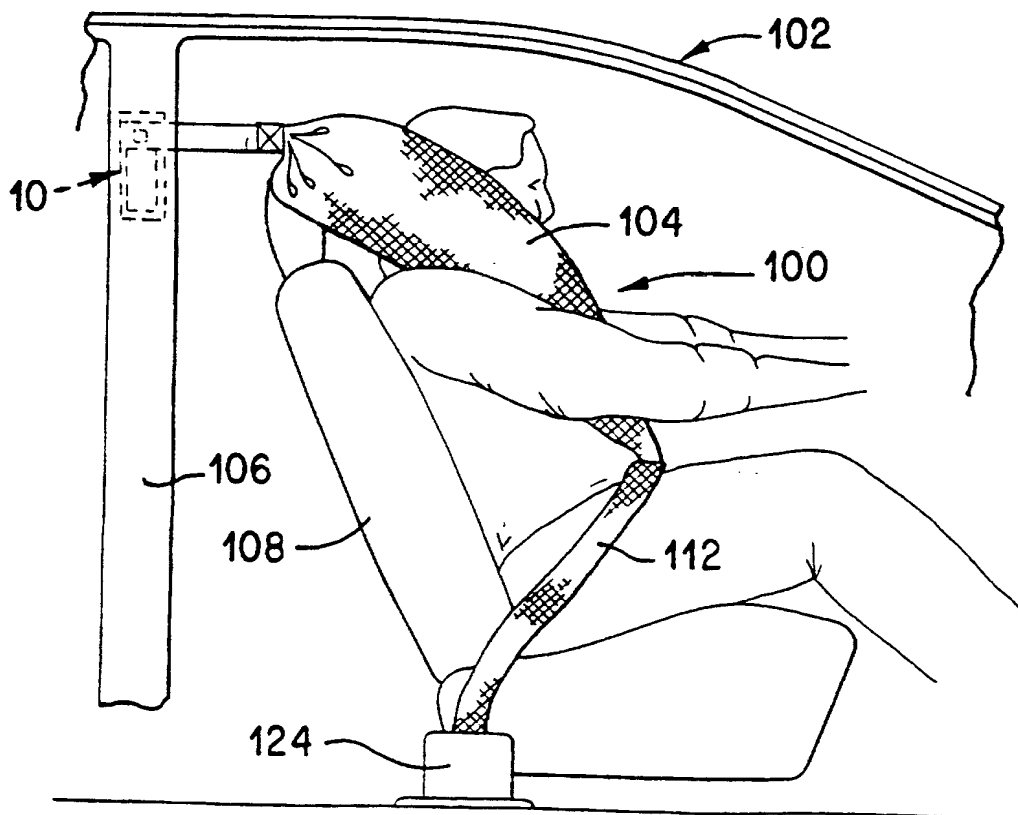
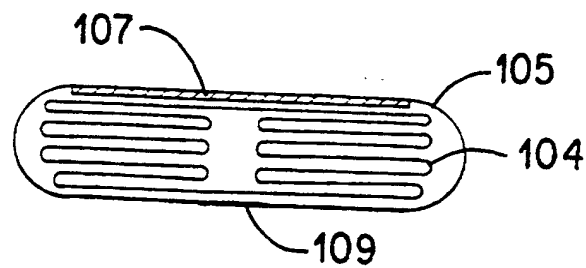
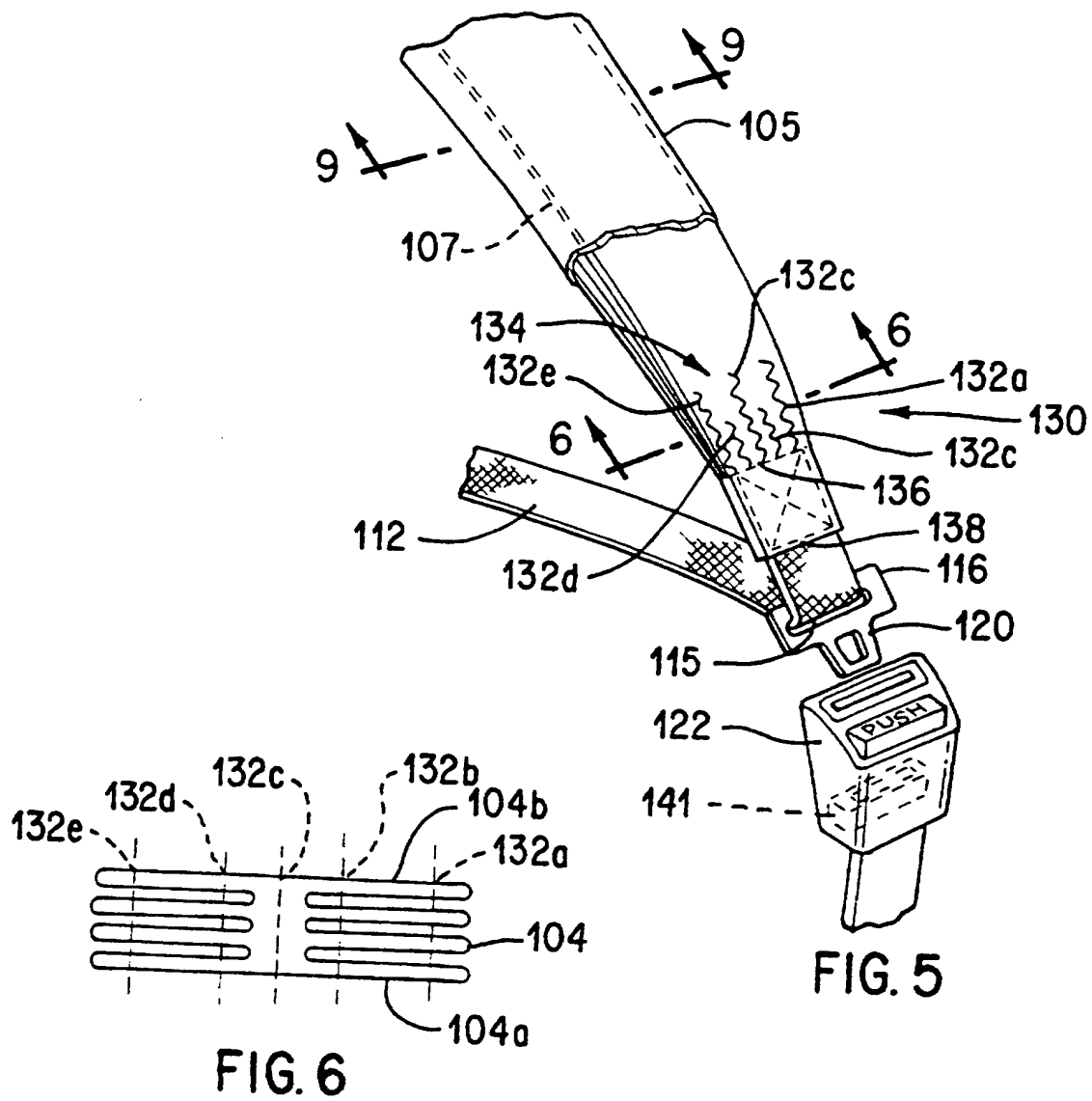


FIG. 4

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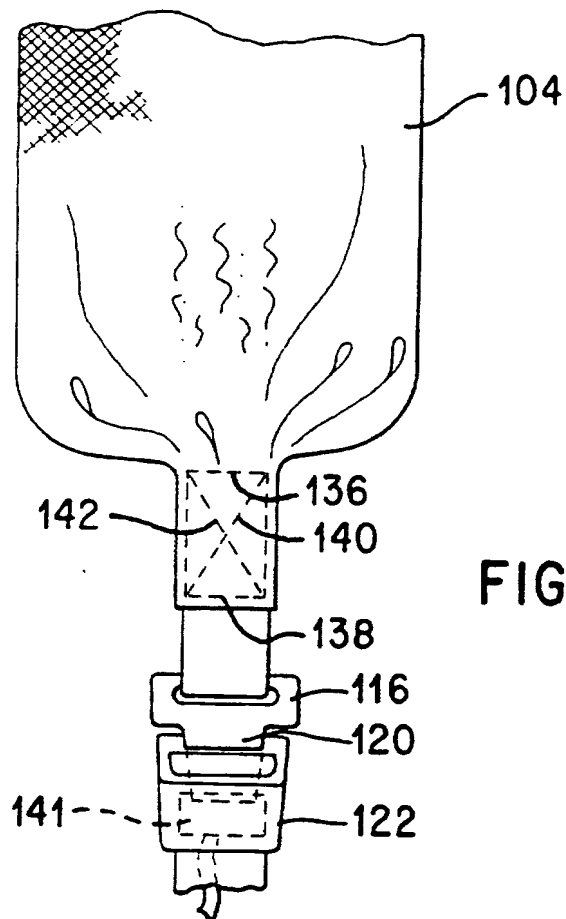


FIG. 7

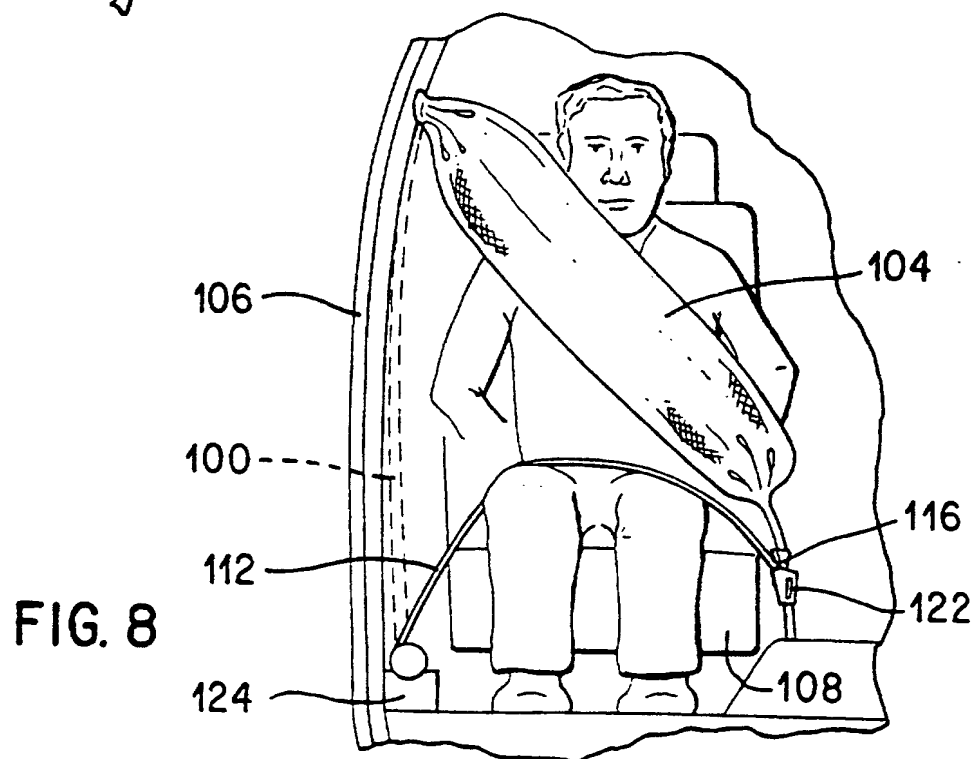


FIG. 8

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/19872

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B60R 21/18, 21/26

US CL :280/733, 737, 808

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 280/733, 737, 808, 730.1, 730.2, 736, 741, 805; 137/68.13, 68.19, 68.23; 222/3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 5,303,953 A (KAMIYAMA ET AL.) 19 APRIL 1994, SEE ENTIRE DOCUMENT.	1 - 1 4 , 1 7 - 21,62,64,65,6 7-69,89-94 ----- 3 5 , 3 8 , 4 2 - 4 5,57,58,60,63, 66,70,71,81,8 4,88,96,98-101

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

01 FEBRUARY 1997

Date of mailing of the international search report

21 FEB 1997

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/19872

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 3,655,217 A (JOHNSON) 11 APRIL 1972, SEE ENTIRE DOCUMENT.	34,36,37,39- 41,44,46,47,49,5 0,53-56,59,78- 80,82,83,85- 87,102-104 ----- 35,38,42- 45,48,51,52,57,5 8,60,61,63,66,70 ,71,81,84,88,96, 98-10 1
Y	US 4,049,935 A (GRUBER) 20 SEPTEMBER 1977, SEE ENTIRE DOCUMENT.	48,51,52,61,84
Y	US 3,897,081 A (LEWIS) 29 JULY 1975, SEE ENTIRE DOCUMENT.	98-101
A	US 3,837,671 A (HAMILTON) 24 SEPTEMBER 1974.	1
A	US 3,848,887 A (FOX) 19 NOVEMBER 1974.	1
A	US 3,874,694 A (STEPHENSON) 01 APRIL 1975.	1

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